SECTION 2

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2. THE HITCHHIKER CARRIER SYSTEM

The HH carrier system implements various modular hardware in mounting customer equipment in the payload bay. HH-S customer equipment is mounted in canisters, on small mounting plates, or directly to the Orbiter adapter beams. HH-C customer hardware is mounted to the HH bridge using standard canister hardware, small experiment mounting plates, or custom-mounting equipment. The standard avionics unit forms a part of both the HH-S and HH-C configurations. This unit provides the electrical interface between the Orbiter and up to six customer units. The weights of the various carrier units and their maximum customer weight capacities are shown in Table 2.1. Actual allowable customer weight depends on detailed analysis of actual mounting configuration and center of gravity. Table 2.1. also shows the weights of the GAS-type beam (attachment hardware for HH-S) and Keel Trunnion attachment hardware (used with HH-C). The attachment hardware weight is not counted in determining reimbursement to NASA for transportation cost.

Customer interfaces for the side-mount and cross-bay versions of HH have been designed to be as similar as possible allowing many customer payloads to be accommodated on either carrier. This results in maximum manifesting flexibility.

An additional HH version, Hitchhiker-JR (HH-J) is available for small instruments which require only canister mounting and do not require real-time ground command or data services. HH-J has customer electrical interfaces similar to GAS and can be accommodated on Shuttle missions where Orbiter electrical services required by the standard HH carrier are not available. HH-J customers are not required to support the control center operations required by the other HH versions and can avoid the cost and effort associated with the necessary equipment and personnel.

TABLE 2.1 HH CARRIER EQUIPMENT CAPACITIES

Carrier Equipment	Maximum Carrier Weight (lbs)	Customer Weight (lbs)	Mounting Surface
Sealed Canister (insulated top plate)	160	200	19.75" Dia.
Sealed Canister (uninsulated top plate)	140	200	19.75" Dia.
Motorized Door Canister	235	170	19.75" Dia.
HH-S Small EMP	55	300	25" x 39"
HH-S Direct Mount	-	700	20" x 40"
HH-C Side Mounting Plate (Experiment)	61	250*	25.6" x 39.5"
(No Brackets)			
HH-C Small Top Mounting Pallet (Exp.)	90	600*	33.38" x 27.45"
HH-C Large Top Mounting Pallet (Exp.)	207	600*	55.65" x 33.38"
(No Brackets)			
Avionics Unit (includes mounting plate & mounting hardware)	236	--	--
HH-C (includes avionics unit, mounting plate and standard MPE)	2165	1200	Custom-mounted

Attachment Hardware	Weight
HH-S GAS Beam, Bays 2-8, 12, 13	70 lbs.
HH-C Bridge Attachment Fittings for Bay 2	365 lbs.
HH-C Bridge Attachment Fittings for Bay 3	418 lbs.

*Specific center of gravity envelope limits weight capability.

2.1 Mechanical Support Systems

HH-S and customer hardware will be side-mounted to the Orbiter payload bay longeron and frame attachment points using GAS-type adapter beams. HH-S carrier components are illustrated in Figure 2.1. HH-C payloads are carried on an across-the-bay structures as described in section 2.1.4.

Existing HH-S equipment is designed to be mounted on the starboard side of the cargo bay in bay locations 2 or 3. These locations are indicated in Figure 2.2 which shows the forward-most available positions in the bay for the GAS adapter beam mounting as well as the X-axis station numbers associated with these positions.

Figure 2.3 depicts an example of a typical structural configuration for HH-S payloads. Figure 2.4 shows a sideview of a typical HH-S payload mounting.

All plates that are to be side-mounted to the Orbiter are parallel to the X-Z plane. The X axis is along the long axis of the Orbiter; positive towards the tail. The Y axis is across the payload bay positive towards the starboard (right) wing. The Z axis completes the coordinate system and is positive moving "up" from the bottom of the Orbiter payload bay. See Figure 2.5.

The dynamic envelope of the cargo bay defines the maximum permitted extent of thermal and dynamic distortions of payload equipment. A maximum static design radius of 88 inches has been established for customer hardware (Figure 2.6). The maximum dynamic envelope radius is 90" (Figure 2.6). The maximum extent of payload equipment out from the sides of the mounting plates (along the Orbiter + X directions) is mission-dependent. It will normally, however, be restricted to the width of the mounting plate to prevent interference with Orbiter integration Ground Support Equipment (GSE).

The following subsections describe the various mechanical accommodations available with the HH-S system.

Hitchhiker-S Carrier Components

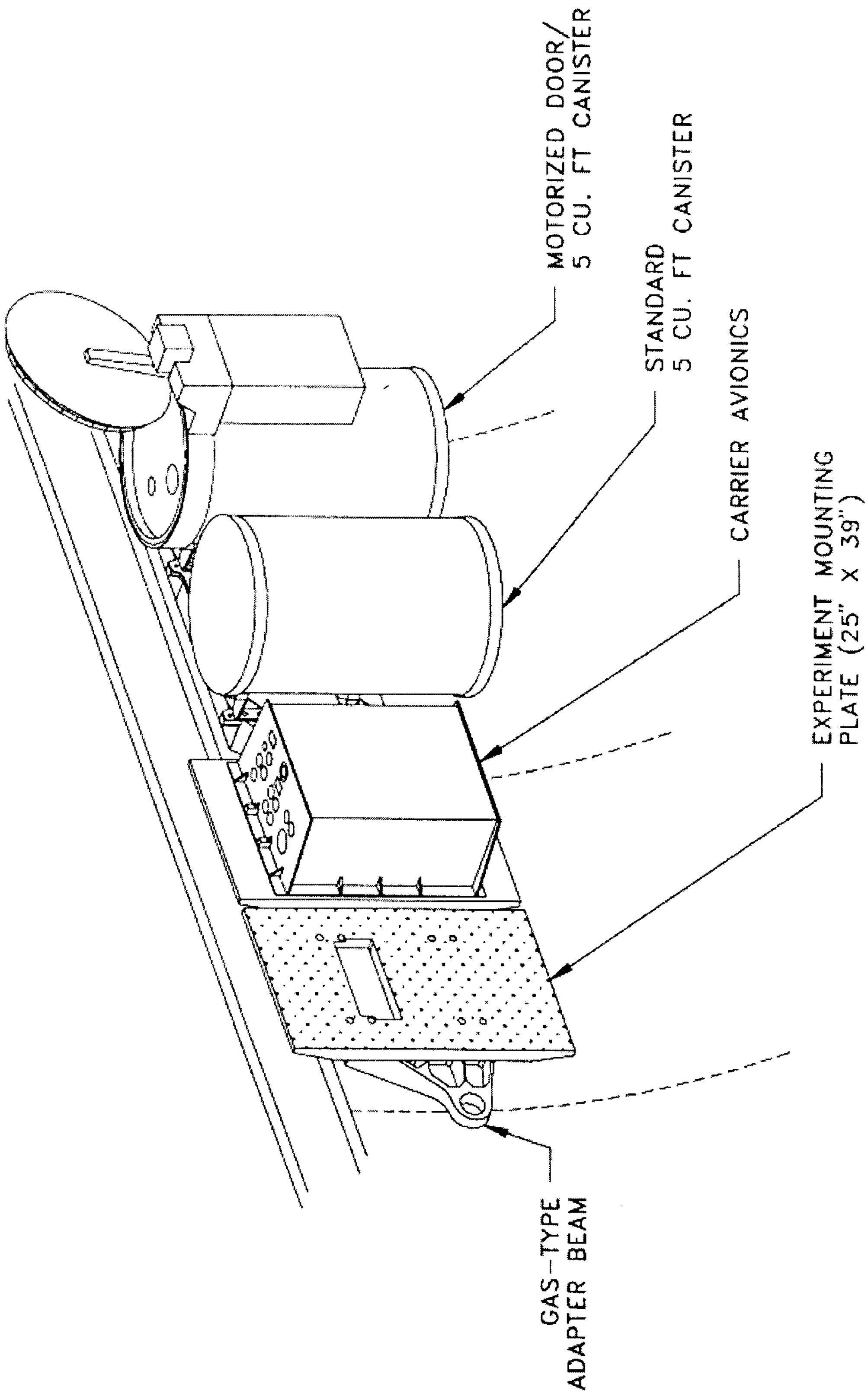


FIGURE 2.1 HITCHHIKER-S CARRIER COMPONENTS

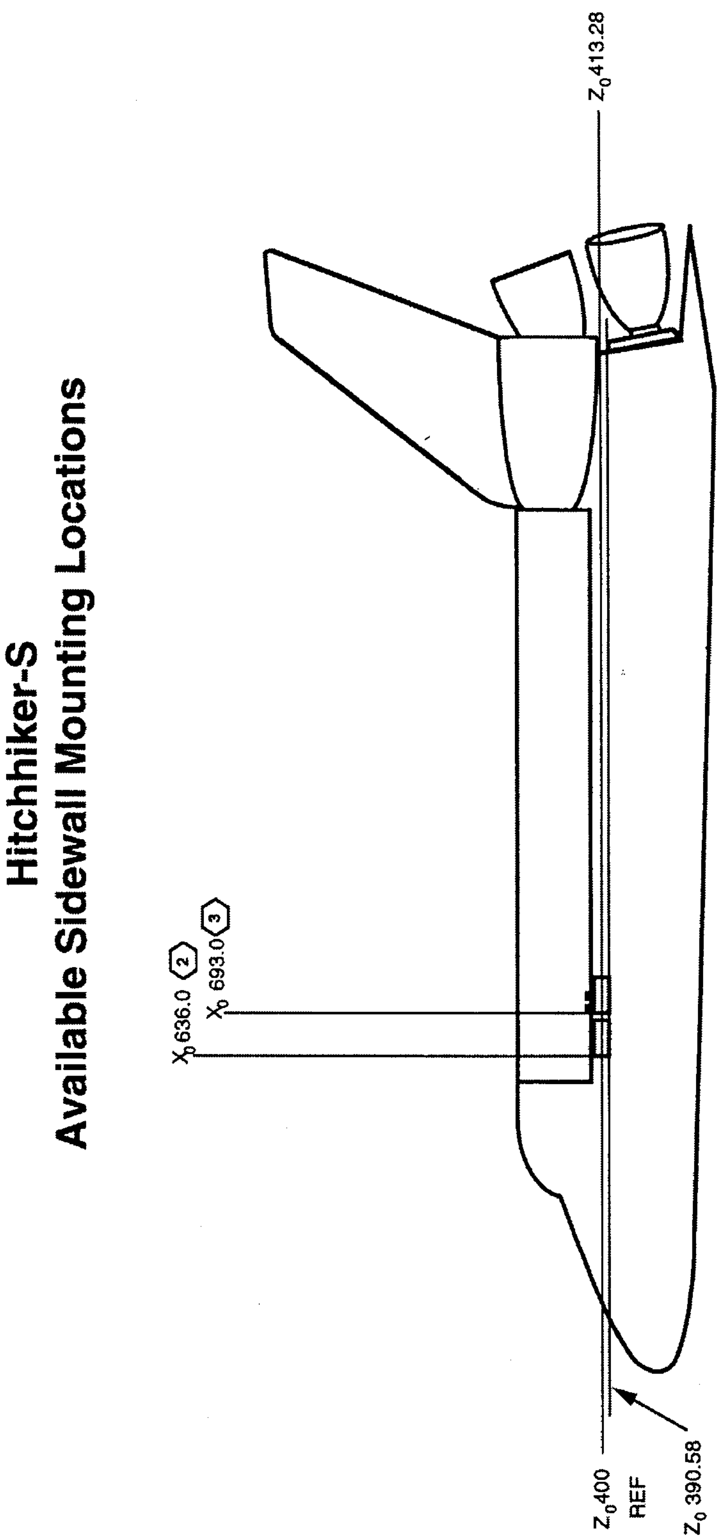


FIGURE 2.2 HITCHHIKER-S AVAILABLE SIDEWALL MOUNTING LOCATIONS

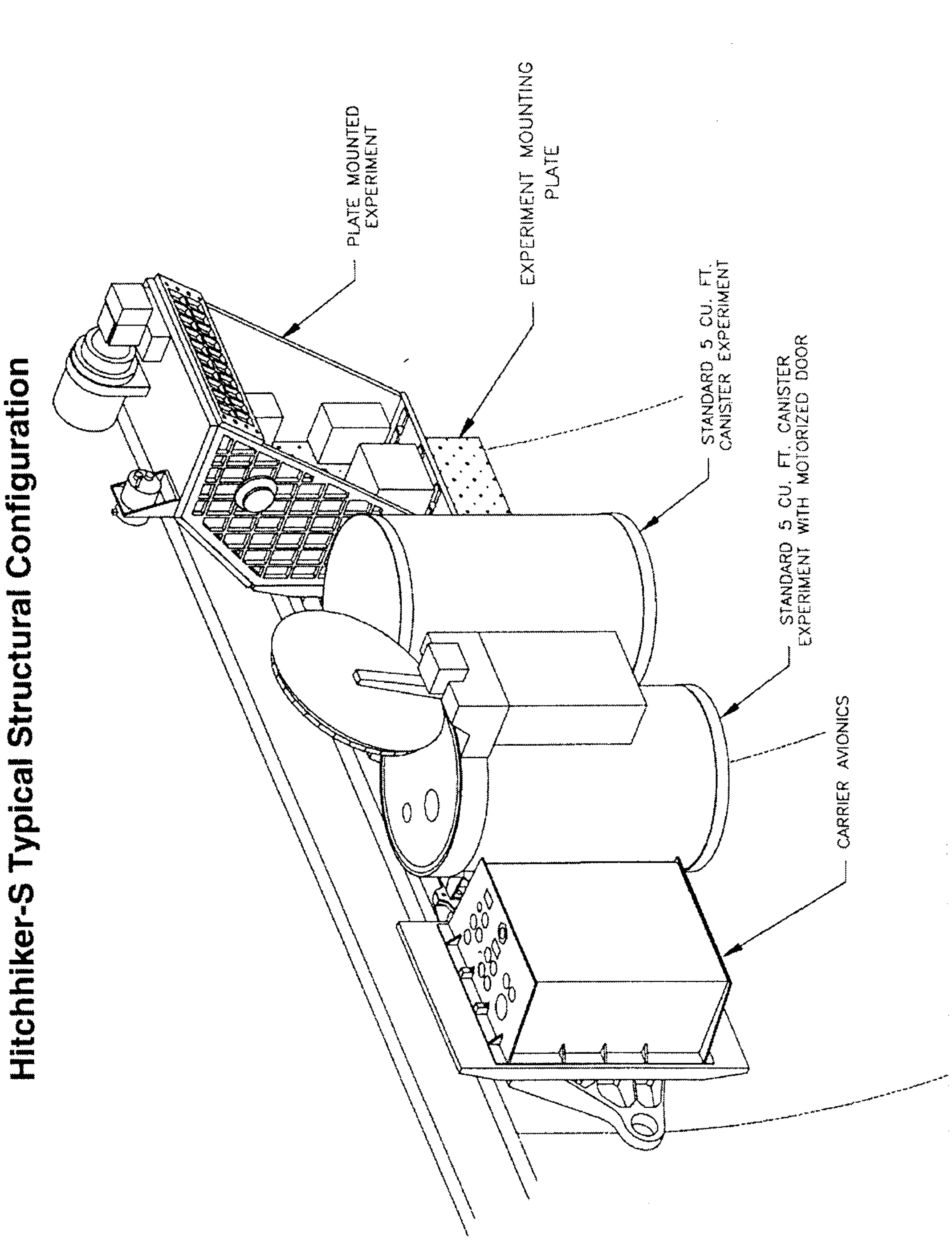
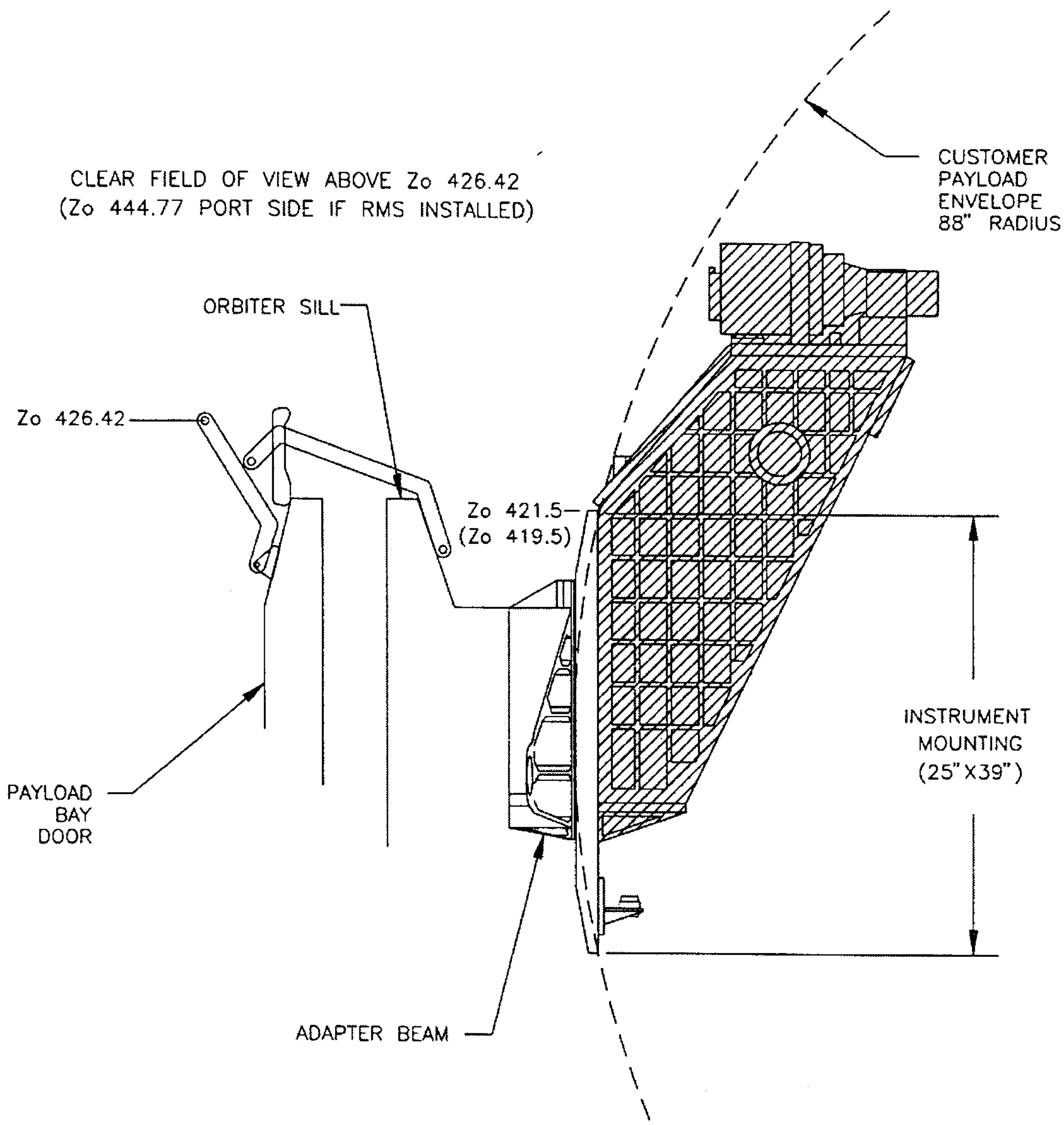


FIGURE 2.3 HITCHHIKER-S TYPICAL STRUCTURAL CONFIGURATION

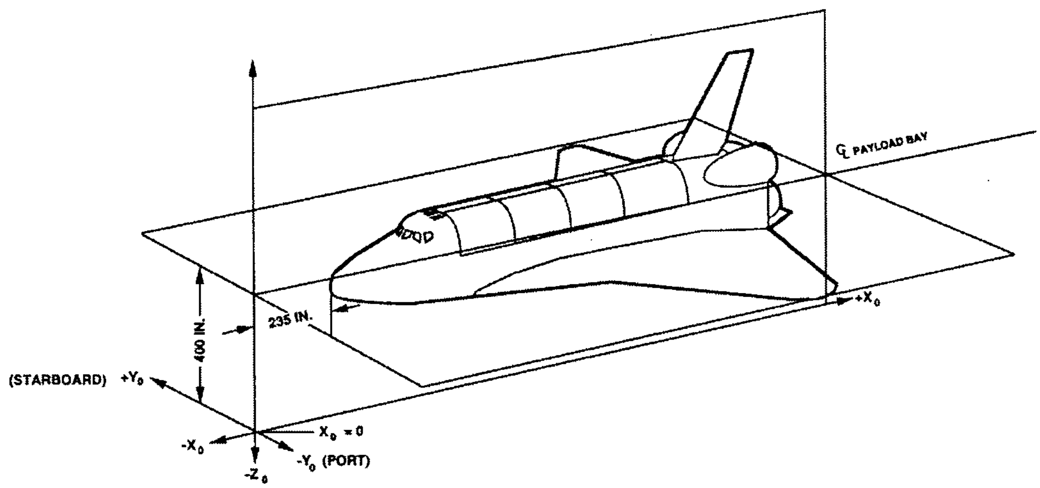
Hitchhiker-S Payload Mounting Concept (Sideview)



NOTE: Zo Coordinate in parenthesis indicates lower mounting position.

FIGURE 2.4 HITCHHIKER-S PAYLOAD MOUNTING CONCEPT (SIDEVIEW)

Orbiter Coordinate System



ORIGIN:	IN THE ORBITER PLANE OF SYMMETRY, 400 INCHES BELOW THE CENTER LINE OF THE PAYLOAD BAY AND AT ORBITER X STATION = 0.
ORIENTATION:	THE X_0 AXIS IS IN THE VEHICLE PLANE OF SYMMETRY. PARALLEL TO AND 400 INCHES BELOW THE PAYLOAD BAY CENTER-LINE. POSITIVE SENSE IS FROM THE NOSE OF THE VEHICLE TOWARD THE TAIL.
	THE Z_0 AXIS IS IN 0THE VEHICLE PLANE OF SYMMETRY, PERPENDICULAR TO THE X_0 AXIS POSITIVE UPWARD IN LANDING ATTITUDE.
	THE Y_0 AXIS COMPLETES A RIGHT-HANDED SYSTEM.
CHARACTERISTICS:	ROTATING RIGHT-HANDED CARTESIAN. THE STANDARD SUBSCRIPT IS 0 (e.g. X_0)

FIGURE 2.5 ORBITER COORDINATE SYSTEM

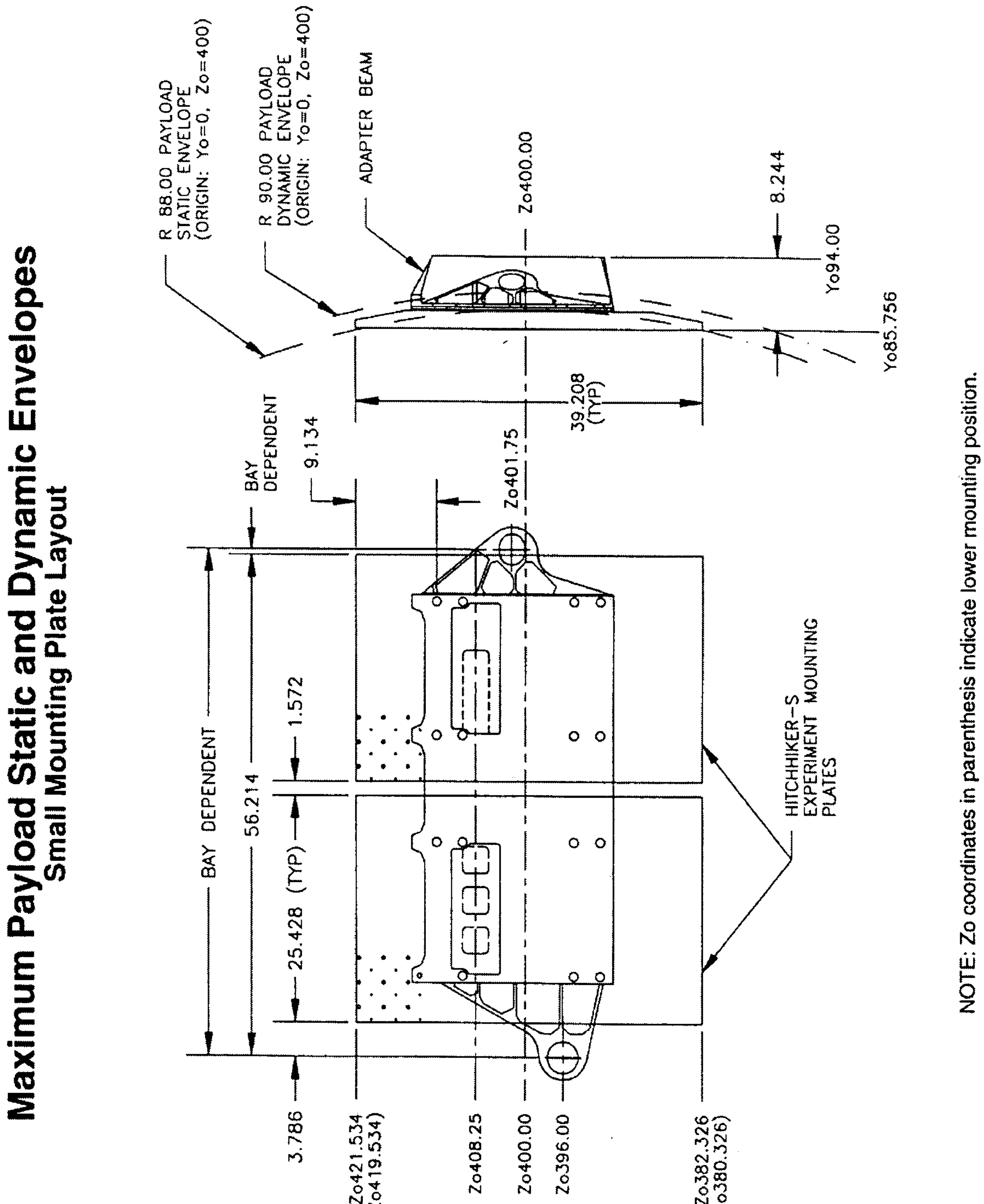


FIGURE 2.6 MAXIMUM PAYLOAD STATIC AND DYNAMIC ENVELOPES

2.1.1 HH Canister

The HH canister is an adaptation of the canister developed by the GAS Program. It is mechanically very similar to a GAS canister and offers the customer the simplest mechanical accommodation in the HH-S system. It is available as a completely closed canister (Figure 2.7) or with an opening lid known as the Hitchhiker Motorized Door Assembly (HMDA) (Figure 2.8). Figure 2.9 shows the canister mechanical and electrical components. Figure 2.10 illustrates the field-of-view restrictions for payloads using the HMDA. Canister extensions to facilitate additional payload volume are available as an optional service and will be considered on a case-by-case basis.

Use of the standard container facilitates safety. The container provides for internal pressure which can be varied from near vacuum to about 1 atmosphere absolute. It also provides thermal protection for the experimental apparatus. The sides of the container may be thermally insulated or may be uninsulated with a white paint surface. The top may be insulated or not, depending upon the customer requirements. The bottom of the container is always insulated.

The experiment mounting plate, which is also the upper end plate of the canister, provides a standardized mounting surface for customer hardware. Any experiment venting will be through the experiment mounting plate. The lower end plate contains ports through which a payload may vent. The HMDA uses a different experiment mounting plate and similar, but different, payload venting.

The weight the canister can support depends upon whether it is mounted for a HH-S or HH-C configuration. For the HH-S configuration, the canister is qualified to support 200 lbs. of payload weight. The HH-C configuration is qualified to carry a total of 400 lbs. for the canister carrier weight and payload weight. If the canister carrier weight to support a payload increases, then the payload weight that can be flown is reduced. For example, a standard insulated canister with an uninsulated top plate weighs about 140 lbs., this would limit the payload to 260 lbs. If the payload required the HMDA, then the payload weight allowed would be reduced by the weight of the HMDA.

2.1.1.1 Container Construction

The standard container is made of aluminum. There is white paint or multilayer insulation on the exterior. The top may or may not be insulated depending on the particular Shuttle mission and needs of the experimenter. The circular top and bottom end plates are 5/8" thick aluminum.

The bottom 3" of the container is reserved for HH-S interface equipment such as interface harnesses and venting systems. This volume is in addition to the 5-cubic foot space available to the experimenter.

The container is a pressurized container capable of:

a. maintaining about 1 atmosphere absolute pressure at all times, (dry nitrogen or dry air),

b. evacuation during launch and repressurization during re-entry (vented).

c. evacuation prior to launch.

d. evacuation on orbit with vacuum being maintained through re-entry.

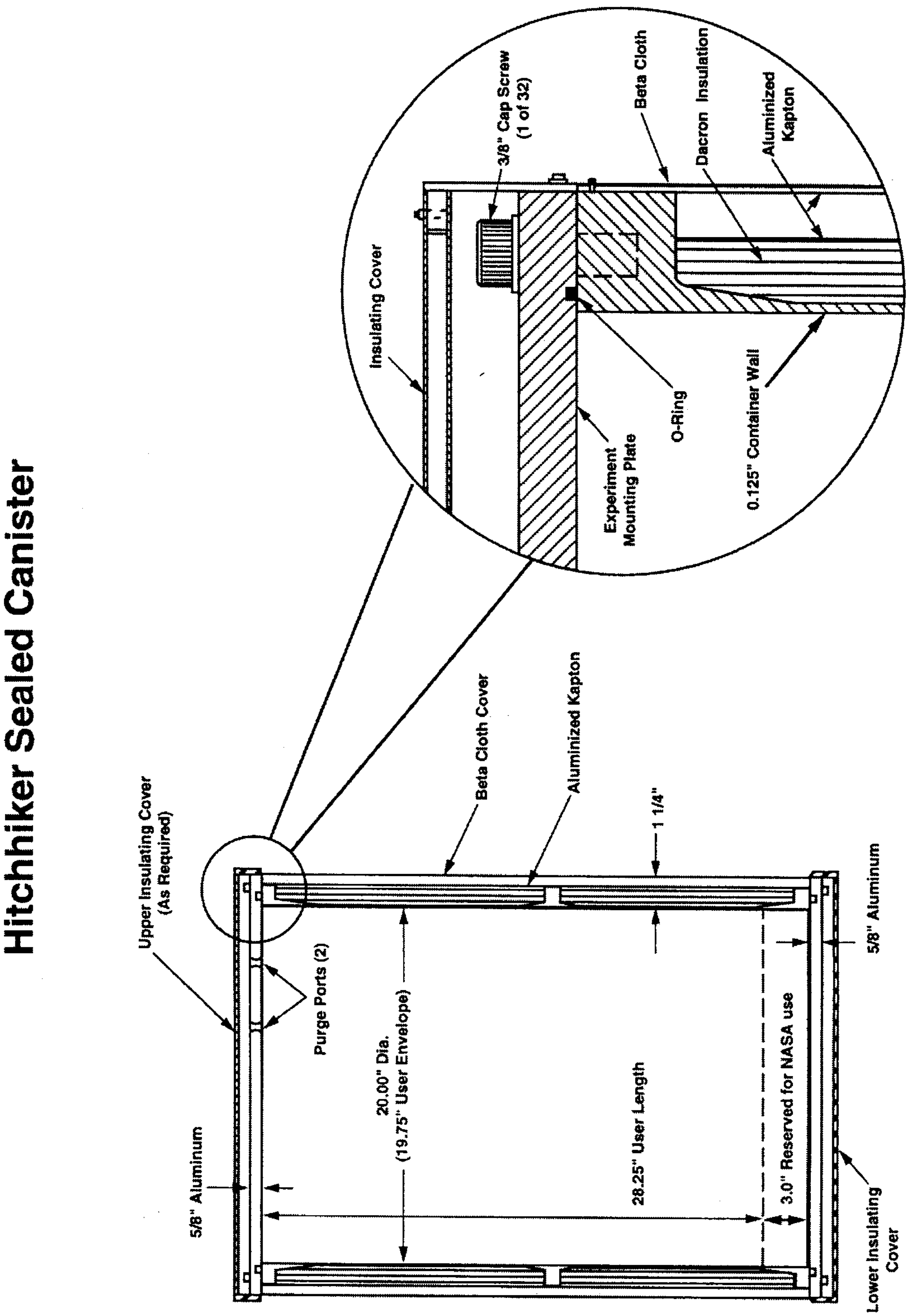


FIGURE 2.7 HITCHHIKER SEALED CANISTER

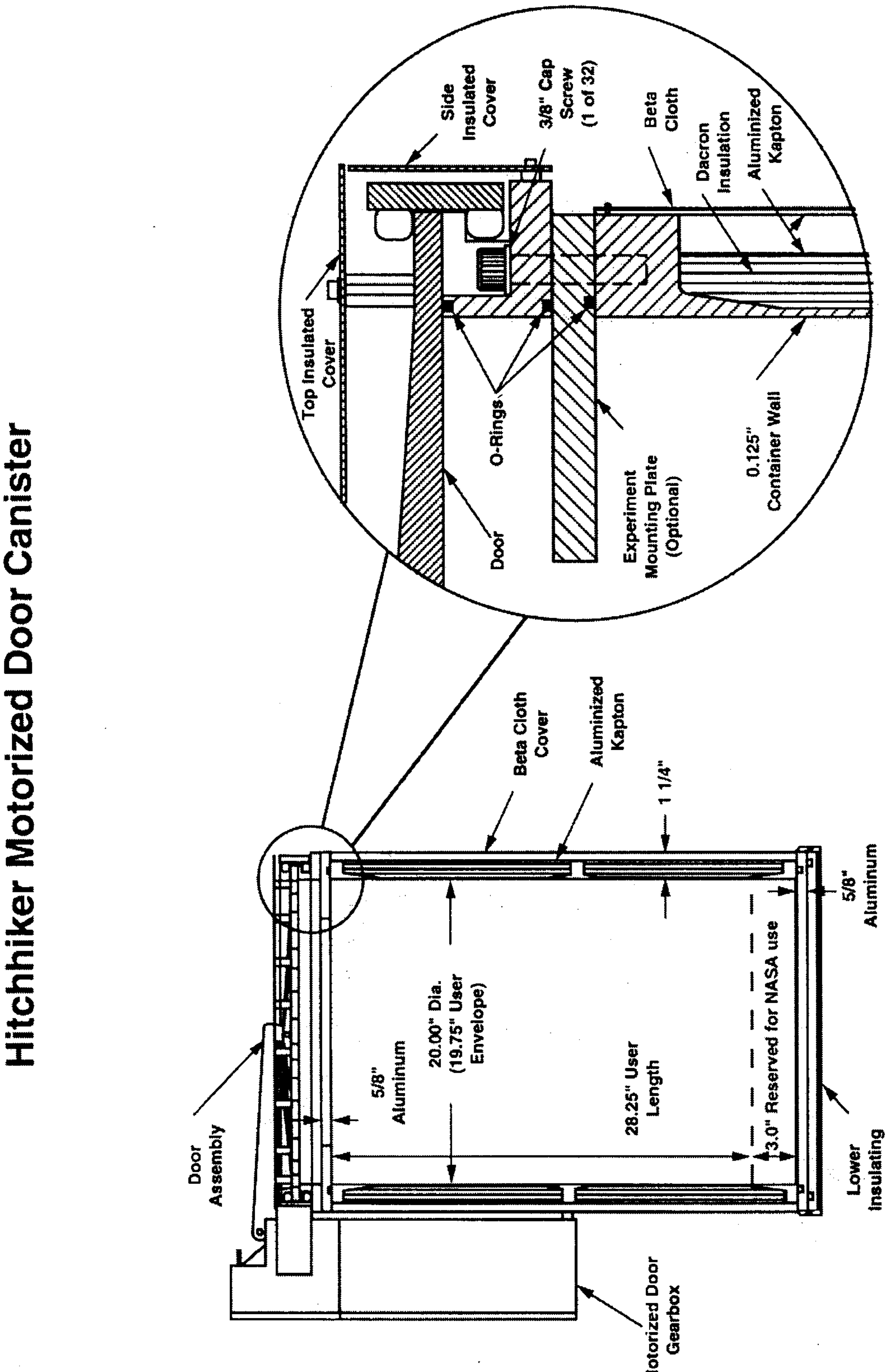


FIGURE 2.8 HITCHHIKER MOTORIZED DOOR CANISTER

Hitchhiker Canister

Mechanical and Electrical Components

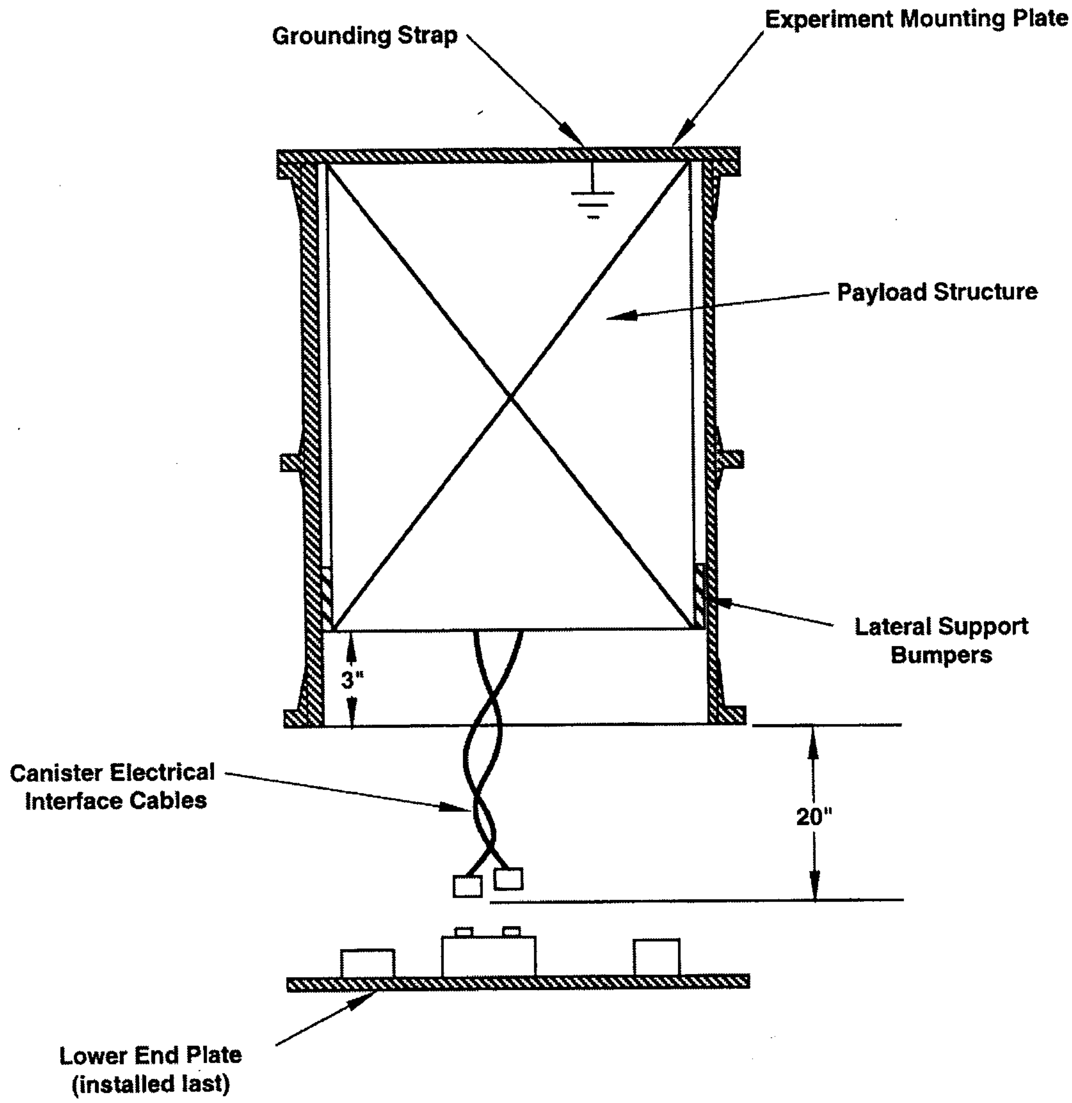
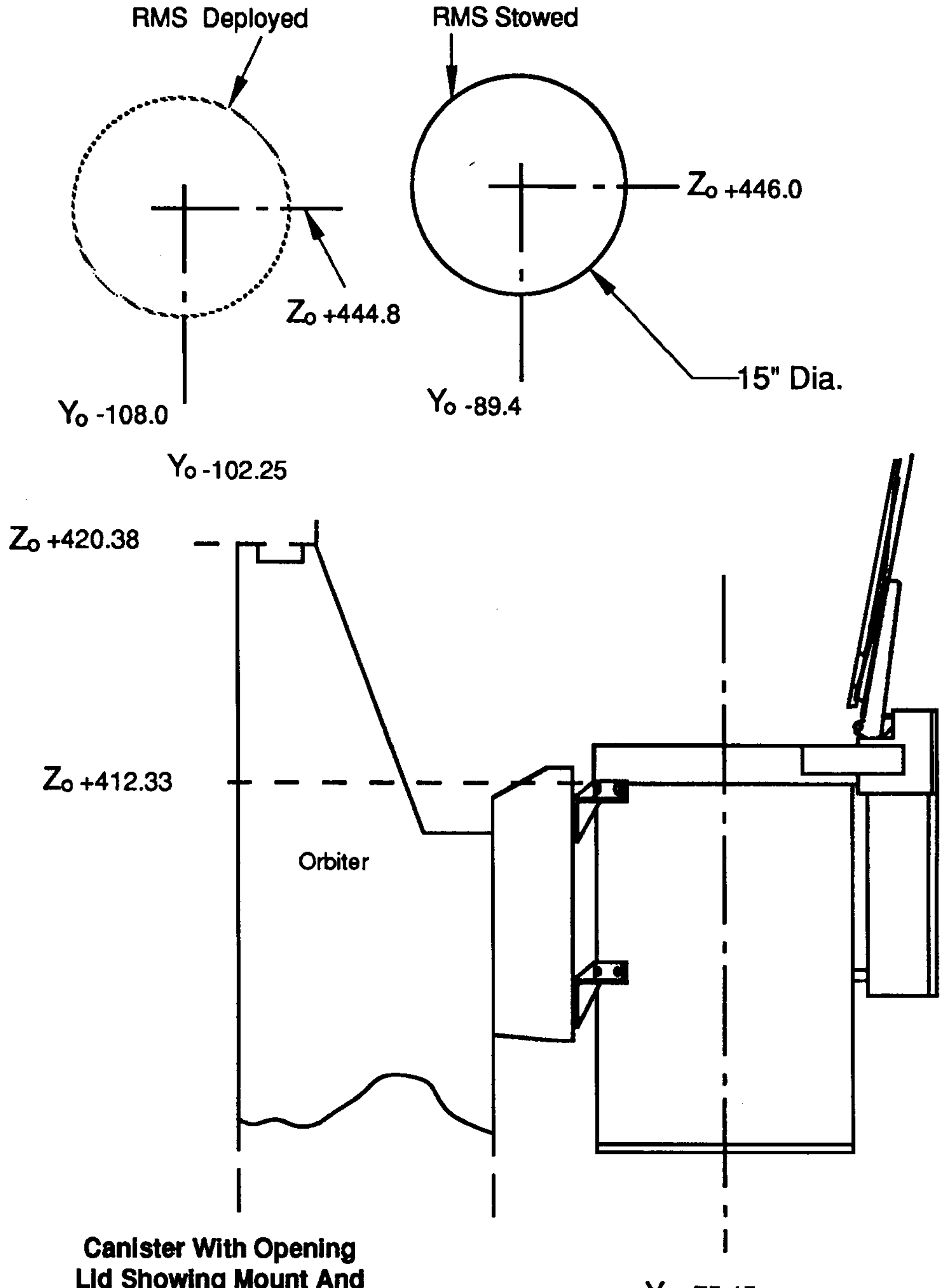


FIGURE 2.9 HITCHHIKER CANISTER

Hitchhiker-S Canister Mounting To Orbiter

View Looking Forward - Port Side



Canister With Opening Lid Showing Mount And Field-of-View Restriction Imposed By RMS

FIGURE 2.10 HITCHHIKER-S CANISTER MOUNTING TO ORBITER

2.1.1.2 Sealed Canister Experiment Mounting Plate

The sealed canister upper end plate (see Figure 2.11) serves four purposes:

a. it seals the upper end of the standard container,
b. it provides a mounting surface for the experimental equipment,
c. it can act as a thermal absorption or radiation surface, and
d. it provides accommodations for experiment box venting when required.

The inner surface of the plate has a hole pattern adaptable for mounting a variety of hardware. Forty-five stainless steel, internally threaded inserts exist for experiment mounting purposes. The experimenter may use any of them in any combination required. The inserts do not go through the plate. They will accept #10 - 32 UNF machine screws to a depth of 0.31 inches. The project is responsible for approving the structural dimensions of the experiment interface and the number and location of mounting screws.

The line from the center of the plate through the two purge ports will always be positioned toward the starboard (right) side of the Orbiter, perpendicular to the Orbiter centerline.

The canister will be purged with dry nitrogen, or dry air, as specified by the customer. Two purge ports are shown on the experiment mounting plate (see Figure 2.11). At least one of these must be unobstructed to allow purged gas to flow through the canister.

The customer must provide a grounding strap from the payload to the experiment mounting plate. Any mounting hole on the experiment mounting plate may be used for grounding.

If safety considerations require that a battery box or other component be vented, it can be plumbed to a special pressure-relief valve turret (illustrated in Figure 2.12). Since the turret can be rotated 360°, the experimenter can pick the most convenient orientation within the plumbing circle shown in Figure 2.11. If no turret is required for the payload, this area will be completely clear and will not affect payload mounting.

The customer must provide attachment points on the bottom of the payload structure for lifting in the inverted orientation by means of a crane and sling. The sling must be provided by the customer. Customers may not alter the mounting plate unless changes have been negotiated with the HH Project Office. As an optional service to be individually negotiated, the top mounting plate may be modified to provide apertures or customer electrical connectors. Customer equipment may be mounted to the top (external) surface of the mounting plate.

Hitchhiker Sealed Canister

Standard Experiment Mounting Plate (Upper End Plate)

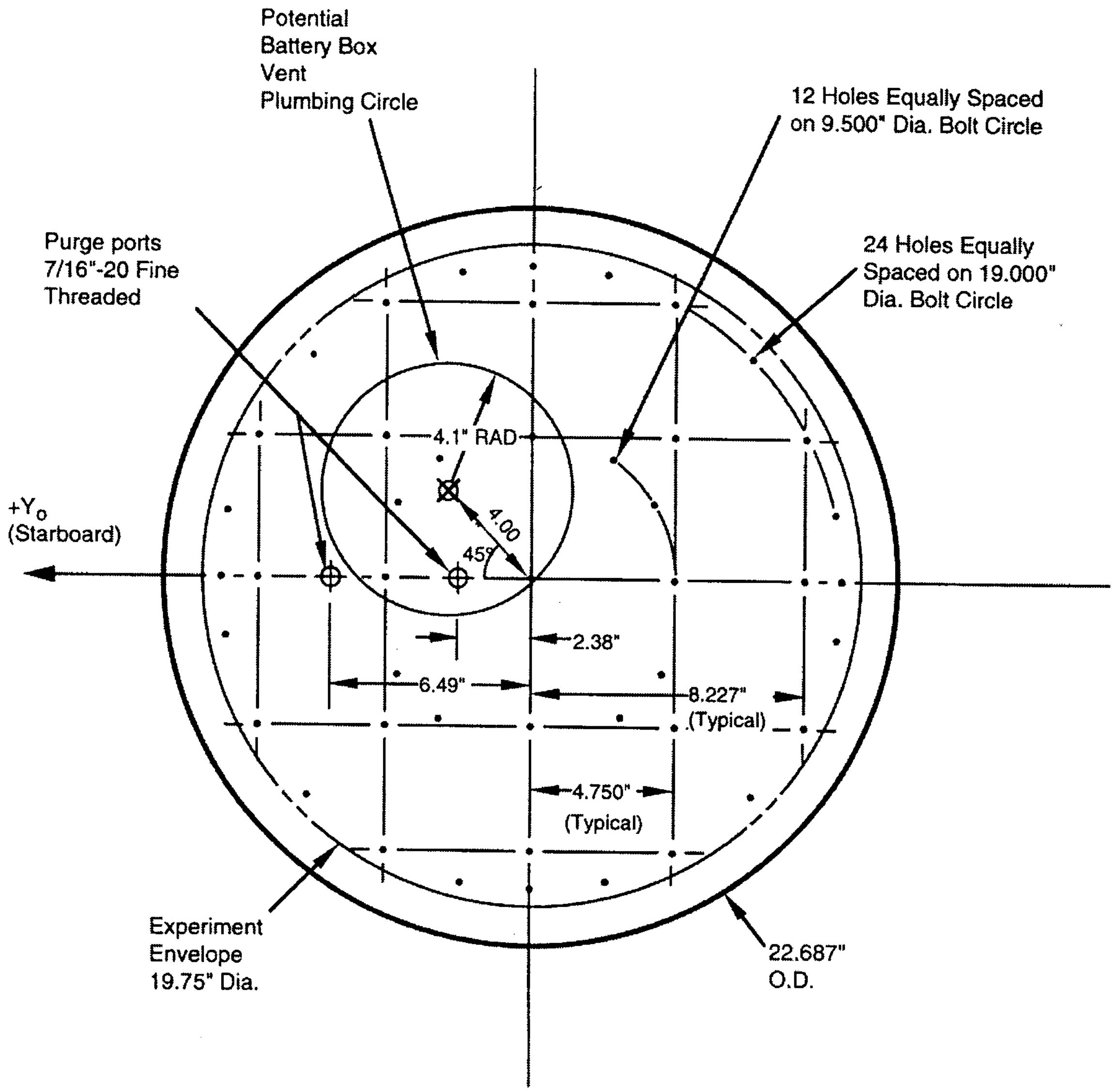


FIGURE 2.11 HITCHHIKER SEALED CANISTER (UPPER END PLATE)

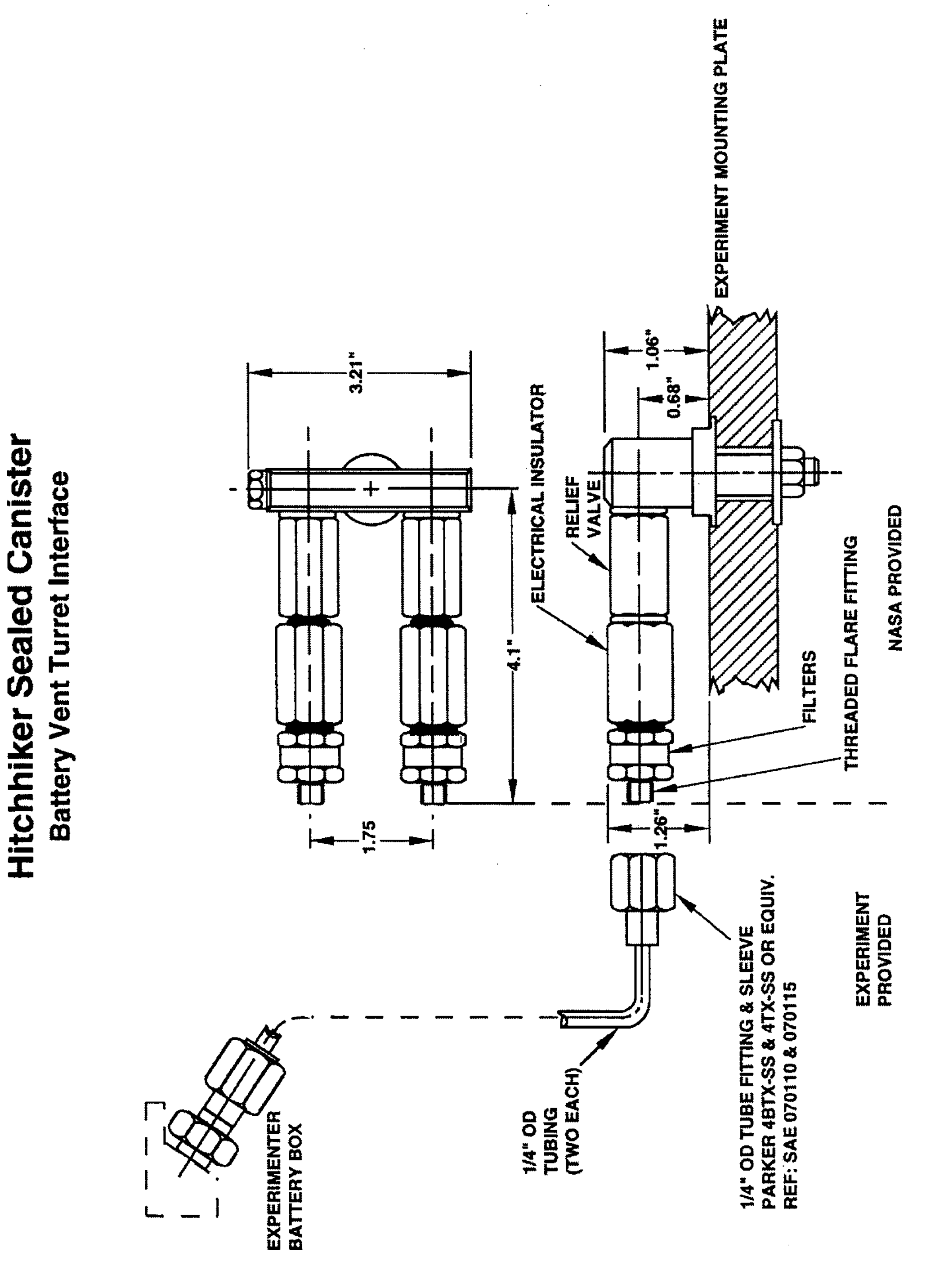


FIGURE 2.12 HITCHHIKER SEALED CANISTER – BATTERY VENT TURRET INTERFACE

2.1.1.3 Opening Lid Canister

A canister may be fitted with a HMDA if the customer payload requires a field of view or exposure to the space environment. The door is opened and closed by ground command as required. The HMDA is capable of maintaining a 15 psi differential (psid) pressure or evacuated environment similar to the standard canister. It is possible to eject packages from a HMDA canister; however, the interface and safety requirements are considerably beyond the scope of this document and must be defined and approved on a case-by-case basis.

HMDA canisters are normally equipped with redundant pressure-relief valves which act to reduce the pressure to less than 1 psid during ascent. Once in orbit, a ground command may be used to open a vent valve and reduce the pressure to less than 0.1 psid prior to opening the door. HMDA canisters normally return with internal vacuum.

The mounting provisions for the opening lid canister are shown in Figure 2.13. Because the contents of the canister are exposed when the door is open, the materials, safety, and Electro-Magnetic Interference (EMI) considerations are essentially the same as for plate-mounted hardware.

For safety considerations, a pressure-relief valve turret designed for use on the HMDA Mounting Plate is available to vent battery boxes or other components (see Figure 2.15). Four venting locations have been provided to accommodate battery box orientation requirements. An experiment may use any one of these four locations. If no turret is required for the payload, this area will be completely clear and will not affect payload mounting.

Multiple interlocks are provided to prevent the door from opening prior to or during ascent. However, in the event of an in-flight door failure, the contents of the canister must be designed to allow safe descent and landing with the door open. The customer is responsible for designing and providing any thermal treatment of exposed surfaces.

2.1.1.4 Canister Orientation

A canister will always be mounted with the experiment mounting plate facing out of the payload bay. There are, however, two different container ground handling orientations. First, during insertion of a payload into the container and the subsequent checkout and transportation, the container's major axis will be vertical. Second, after the container is installed in the Orbiter bay, the container's orientation will become Orbiter dependent, i.e., the major axis of the container will be perpendicular to that of the Shuttle.

Care should be taken in experiment design to assure that systems that are sensitive to ground orientations, such as wet cell batteries, are properly oriented in the experiment. The customer should inform the HH staff of any special payload orientation requirements which must be met prior to installation in the Orbiter.

2.1.1.5 Lateral Load Support

Because the experiment structure will be cantilevered from the experiment mounting plate, radial loads at the free end of the experiment structure must be supported by at least three equally spaced bumpers between the experiment structure and the canister. Figure 2.16 illustrates one possible bumper design configuration.

The customer is responsible for providing bumpers as part of the experiment hardware. Bumper design should be in accordance with the following guidelines:

a. A minimum surface area of 4 in^2 (2" x 2") should be used for each bumper pad.

b. The bumper face should have a 10-inch radius so that it will fit snugly when adjusted against the 20-inch diameter container.

c. Where the bumper contacts the container wall, it should be faced with a resilient material at least 1/8 inch thick to protect the container. If the container is to be evacuated, select a non-outgassing material such as viton. If the bumper face is not round, every corner should have a minimum radius of 0.40 inches.

d. It is very important to provide a positive locking device for the bumpers. Do not depend on friction or a set screw alone to hold them in place.

e. After installing the payload in the container, bumper adjustment should be easily accessible from the open lower end of the container.

2.1.1.6 Center of Gravity (CG) Considerations

To minimize the amount of analysis required for a particular mission, the composite CG of a canister and payload must be constrained within certain limits. The CG envelope is shown in Figure 2.14.

Opening Lid Canister
Experiment Mounting Plate

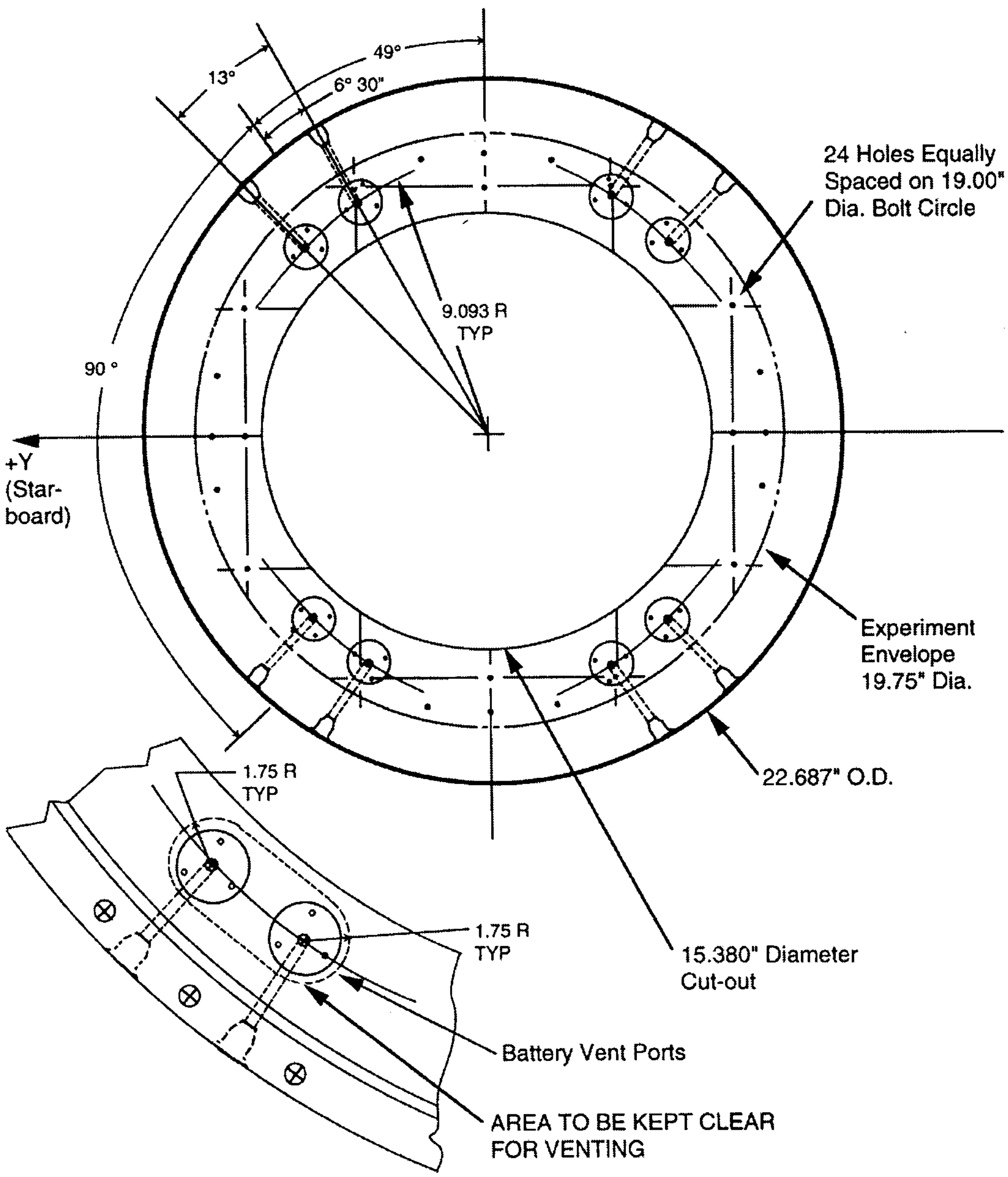


FIGURE 2.13 OPENING LID CANISTER – EXPERIMENT MOUNTING PLATE

Canister CG Envelope
Adapter Beam or Bridge Mounting

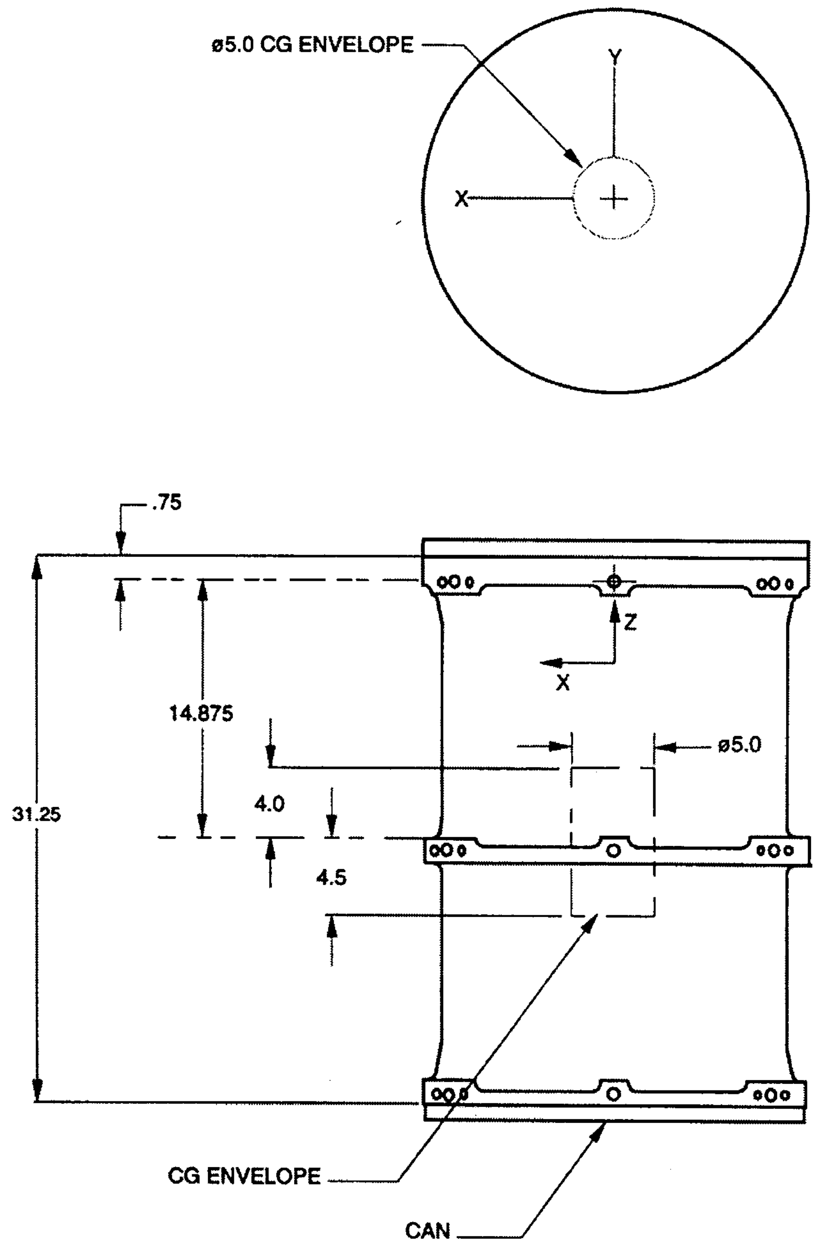


FIGURE 2.14 CANISTER CG ENVELOPE-ADAPTER BEAM OR BRIDGE MOUNTING

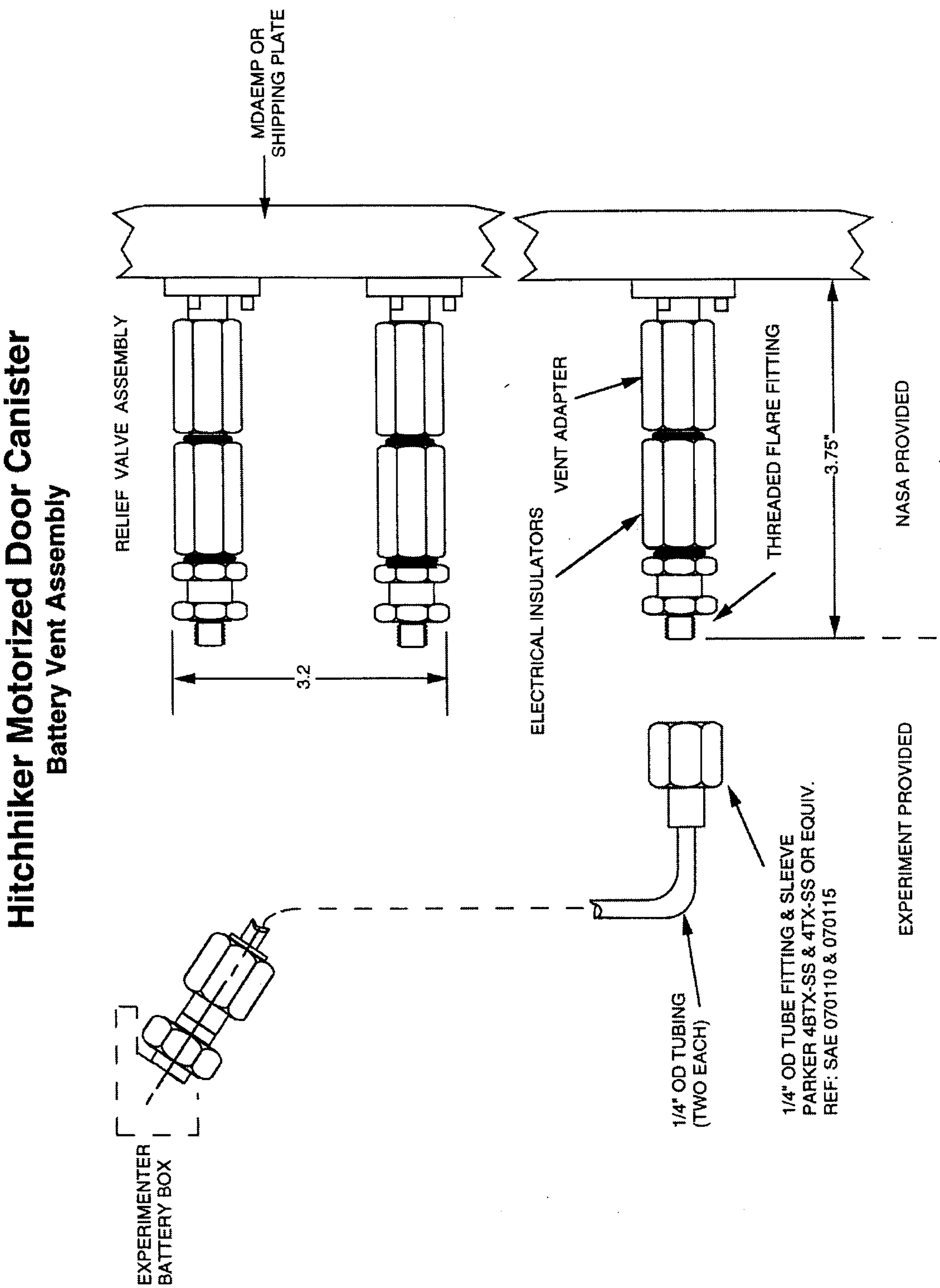


FIGURE 2.15 HITCHHIKER MOTORIZED DOOR CANISTER – BATTERY VENT ASSEMBLY

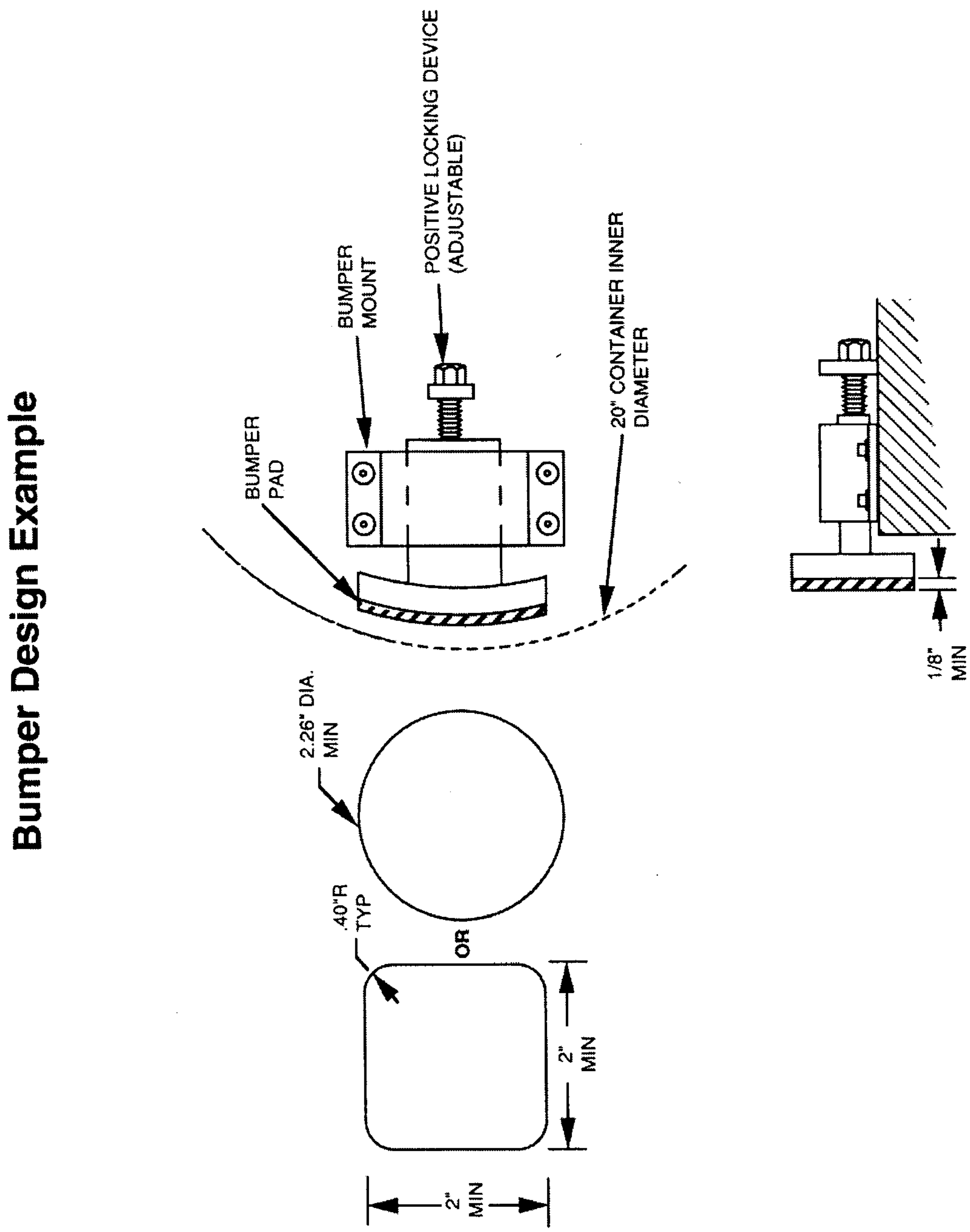


FIGURE 2.16 BUMPER DESIGN EXAMPLE

2.1.1.7 Customer Emblems

HH customers may attach a logo or emblem to the exterior of their equipment. Emblems may also be attached to the exterior of canisters containing customer equipment. The canister emblems should be on a .010 inch Lexan sheet 11 inches square. Emblem artwork must be submitted to GSFC for NASA approval. Materials used for emblems must meet all Space Shuttle payload bay materials requirements.

2.1.2 Plate Mounting

Experiment packages which are not best suited for the canister approach may be mounted on a plate (see Figure 2.17). A small HH-S plate is capable of supporting experiment packages of up to 300 pounds, mounted on an area 25" x 39". Customer equipment is attached to the core plate using a grid hole pattern on 2.756" (70-mm) centers with 3/8" - 24 UNF stainless steel bolts. The bolts are supplied by the HH Project. A similar matrix of #10 - 32 mounting bolt locations will be used by the HH staff to route interface cables as well as intercomponent harnessing and plumbing. The experiment structural dimensions and attachment points at the mounting plate interface must be reviewed for acceptance by the HH Project.

2.1.2.1 Experiment Package Integrity

The package must be designed, fabricated, inspected, analyzed, and tested to demonstrate the ability to constrain, or to contain, the elements of the experiment package during launch, flight, and landing. All customer equipment shall be designed to withstand limit acceleration load factor limits as stated in Section 3.1.1.3.2. Also refer to Random Vibration Verification Levels given in Section 3.1.1.5.3 (Table 3.6).

2.1.2.2 Experiment Package Volume

Specific volume restrictions other than those provided in Section 2.1 are not generally placed on customer equipment since the equipment mass and CG location are the controlling factors. In general, the experiment CG should be located as close to the mounting interface as practical. The complexity of the weight/CG relationship, the possibility of multiple customers per plate, manifesting considerations, and other factors require that the HH-S staff perform accommodation assessments on a case-by-case basis. Guidance will be provided to determine specific equipment design and accommodation details as part of the normal mechanical interface documentation exchange.

Hitchhiker-S Experiment Mounting Plate

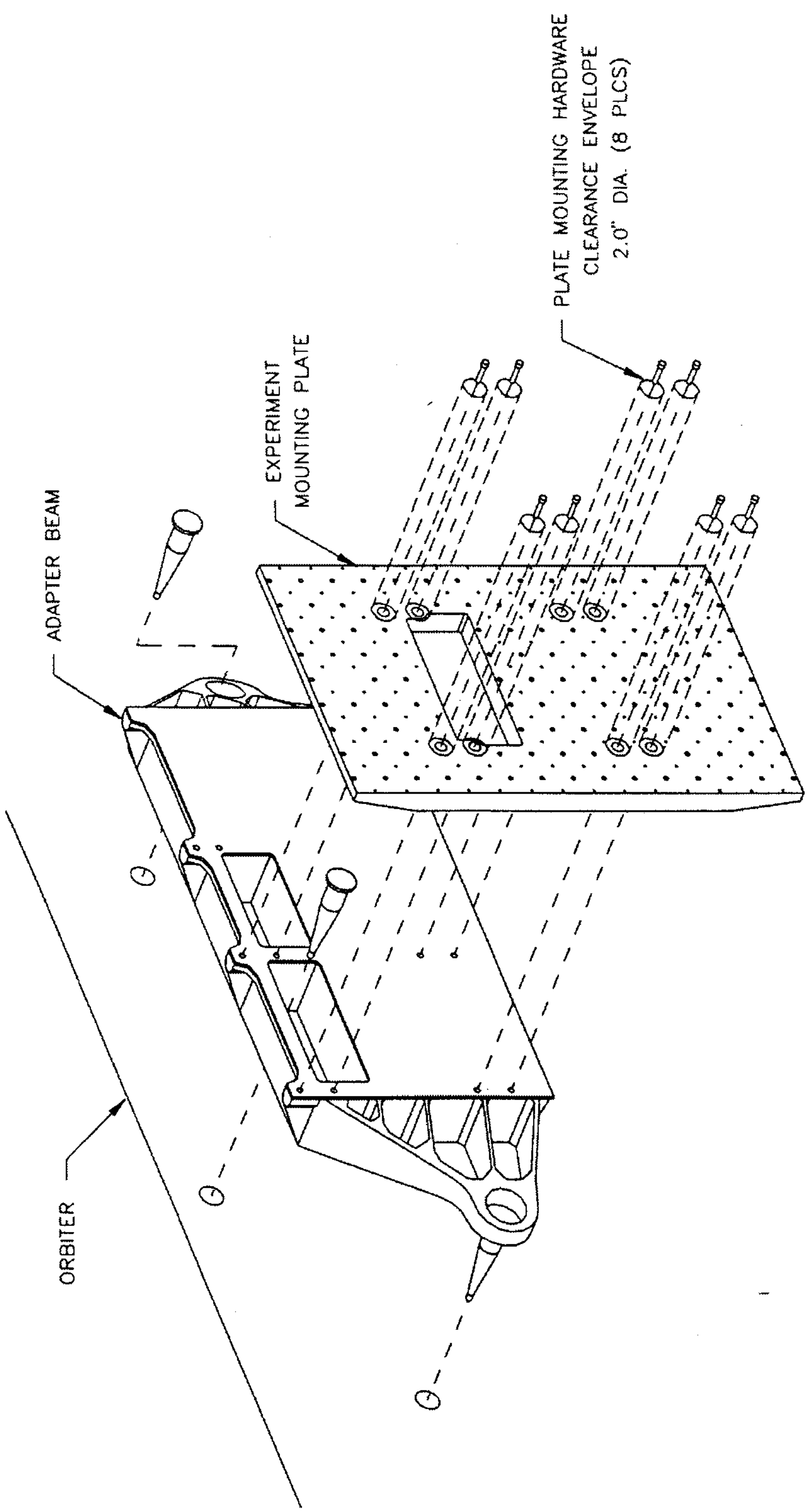


FIGURE 2.17 HITCHHIKER-S EXPERIMENT MOUNTING PLATE

2.1.2.3 Mounting Bolt Loading Limitations

The mounting bolts must be included in the payload stress and fracture analysis (see Section 3.0). Bolt strength and material data will be supplied by the HH Project.

2.1.3 Direct Mounting of Experiment Package

The maximum weight-carrying configuration in the current HH-S system is accomplished by mounting the customer's flight unit directly to the Adapter Beam Assembly (ABA). This mode will accommodate up to 700 pounds but requires detailed case-by-case analysis and approval. The mounting hardware between the experiment package and the ABA will be supplied by the HH Project. The available experiment mounting locations are noted in Figure 2.18.

2.1.3.1 Experiment Package Integrity

See 2.1.2.1 for design considerations.

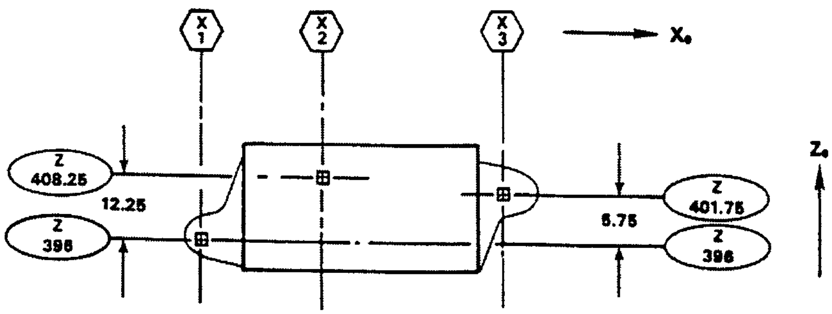
2.1.3.2 Experiment Package Volume and Mounting Limitations

The experiment volume in the direct mount configuration can be somewhat higher than in the plate mount setup; however, it is similarly restricted as described in subsections 2.1.2.2 and 2.1.2.3. The HH staff provides assistance in adapting customer hardware to the ABA interface and defining CG and volume restrictions. Direct-mount payloads are normally designed to be mounted on the adapter beam after the beam is installed in the Orbiter. The mounting scheme must be simple and involve captive fasteners. In the event that a payload is designed to mount on the beam prior to Orbiter installation, adequate access to the longeron bolts must exist. Special lifting equipment for hoisting the payload/beam combination must also be provided.

2.1.4 HH-C Structure

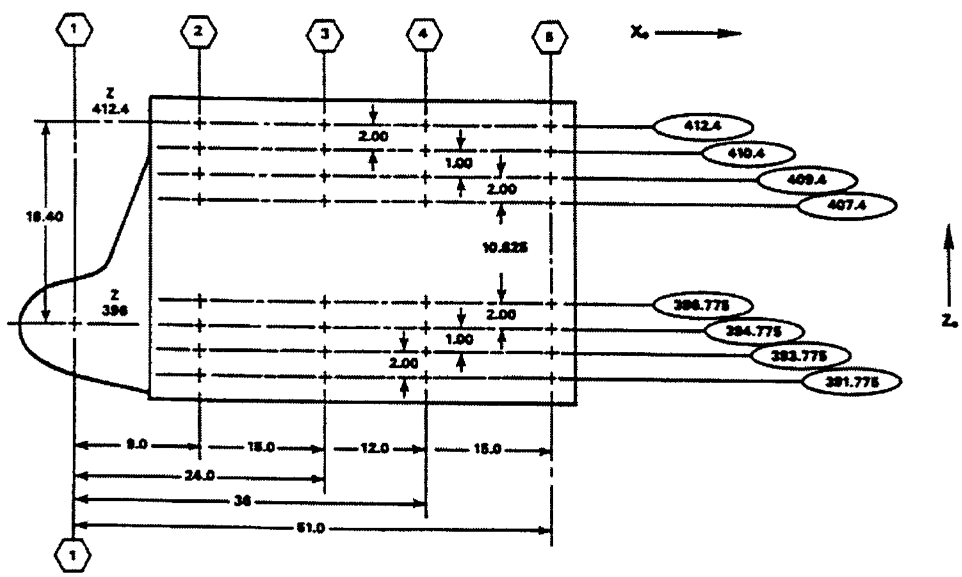
The HH-C cross-bay carrier is implemented using a truss structure (Figure 2.19) called the Hitchhiker Bridge Assembly (HHBA). The HHBA is similar to other Mission Peculiar Experiment Support Structure (MPESS) structures used on Spartan, GAS, Materials Science Laboratory (MSL), and other NASA payload programs and consists of an upper support structure and a lower support structure. The lower structure is normally attached to the upper structure at the launch site. During integration and transportation to the launch site, the upper structure is mounted on a special dolly (see Figure 2.20) which allows easier access and handling.

Adapter Beam Mounting Interfaces



X	X AXIS BAY							
	1	2	3	4	5	6	7	8
1		636.0	693.0	750.0	807.0	863.0	919.0	979.5
2		649.0	715.0	776.90	833.0	892.5	951.0	1011.40
3		693.0	750.0	807.0	863.0	919.0	979.5	1040.0

Longeron Bolt Access Locations



X	X AXIS BAY							
	1	2	3	4	5	6	7	8
1		636.0	693.0	750.0	807.0	863.0	919.0	979.5
2		645.0	702.0	759.0	816.0	872.0	928.0	988.5
3		660.0	717.0	774.0	831.0	887.0	943.0	1003.5
4		672.0	729.0	786.0	843.0	899.0	955.0	1015.5
5		687.0	744.0	801.0	858.0	914.0	970.0	1030.5

Adapter Beam Mounting Locations

FIGURE 2.18 ADAPTER BEAM MOUNTING INTERFACES

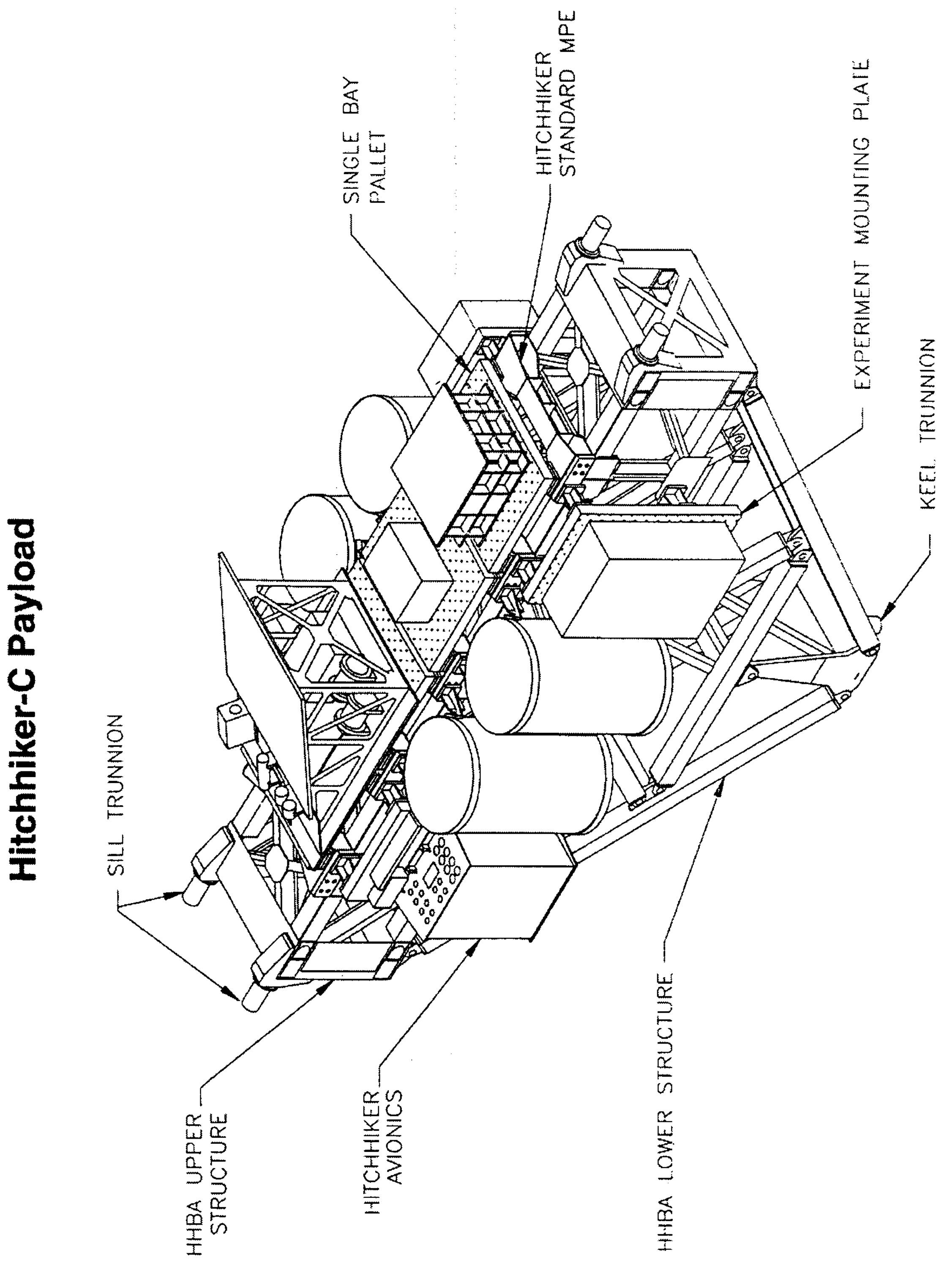


FIGURE 2.19 HITCHHIKER-C PAYLOAD

HHBA Upper Structure on Shipping Dolly

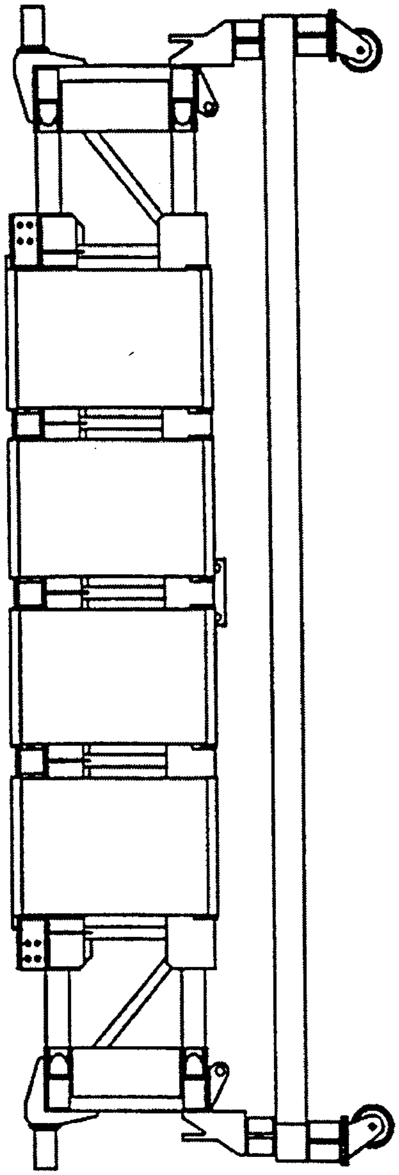


FIGURE 2.20 HHBA UPPER STRUCTURE ON SHIPPING DOLLY

2.1.4.1 Standard HHBA

Attachment of payload equipment to the HHBA is done by means of special Mission Peculiar Equipment (MPE), structure elements which can be attached to the HHBA in five different locations spaced 28.20 inches apart across the top and sides of the structure. The standard MPE has eight positions on the sides of the HHBA for side experiment mounting plates and canisters. However, one experiment mounting plate position is reserved for the HH avionics. Of the remaining seven positions, three can be used for side experiment mounting plates or canisters. The other four positions can only be used for canisters. The HHBA and MPE are un-insulated and can experience large temperature deviations during a mission. For this reason, special mounting brackets are used to attach the plates and canisters to the MPE. The brackets provide thermal isolation and allow for thermal expansion when plates or canisters are temperature controlled.

The top of the MPE structure has positions for two sizes of top plates. It will accommodate two large top plates, four small top plates or combination thereof. Customers considering accommodation on the HHBA should request drawing number GE1550253 from the HH Project for additional detailed information beyond what is listed in the following sections.

2.1.4.3 HH-C Canisters

Canisters identical to those specified for HH-S can be used with the HH-C. The canister is rotated 90 degrees about the Z axis in the HH-C case. All possible canister locations are shown in Figures 2.21, 2.22, and 2.23. Figure 2.21 shows the HH-C Canister Locations. Figure 2.22 shows the HH-C Canister and Mounting Plates, and Figure 2.23 shows the HH-C Canister highlighting the Y-Axis Coordinates and Field-of-View Restrictions

2.1.4.4 HH-C Side Mounting Plates

The HH-C side mounting plates (shown in Figure 2.24) are functionally identical to, although not interchangeable with, the small HH-S mounting plates. The plates are 25" x 39" and can support up to 250 pounds. The "Y" and "Z" axis coordinates of these plates and the field-of-view restrictions are shown in Figure 2.25.

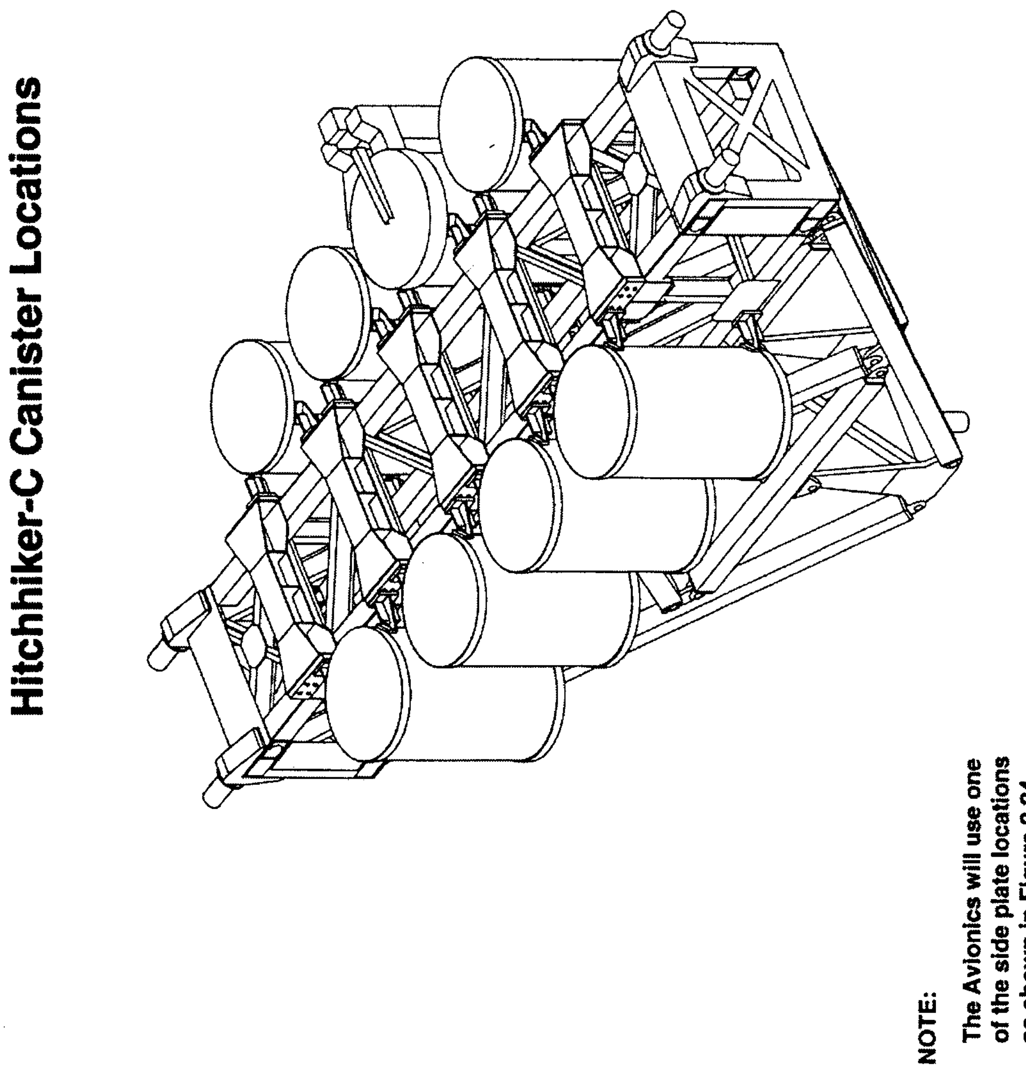


FIGURE 2.21 HITCHHIKER-C CANISTER LOCATIONS

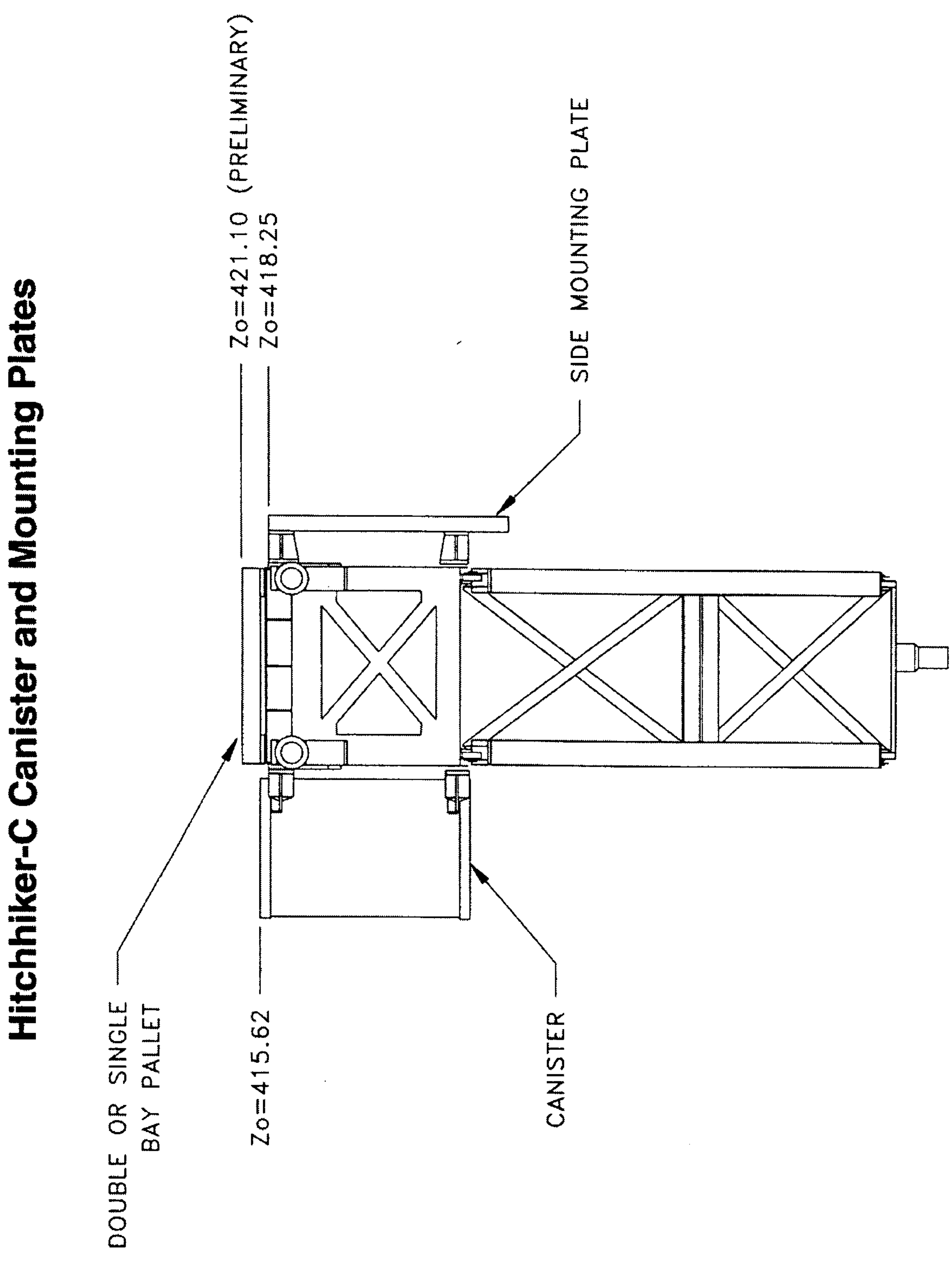


FIGURE 2.22 HITCHHIKER-C CANISTER AND MOUNTING PLATES

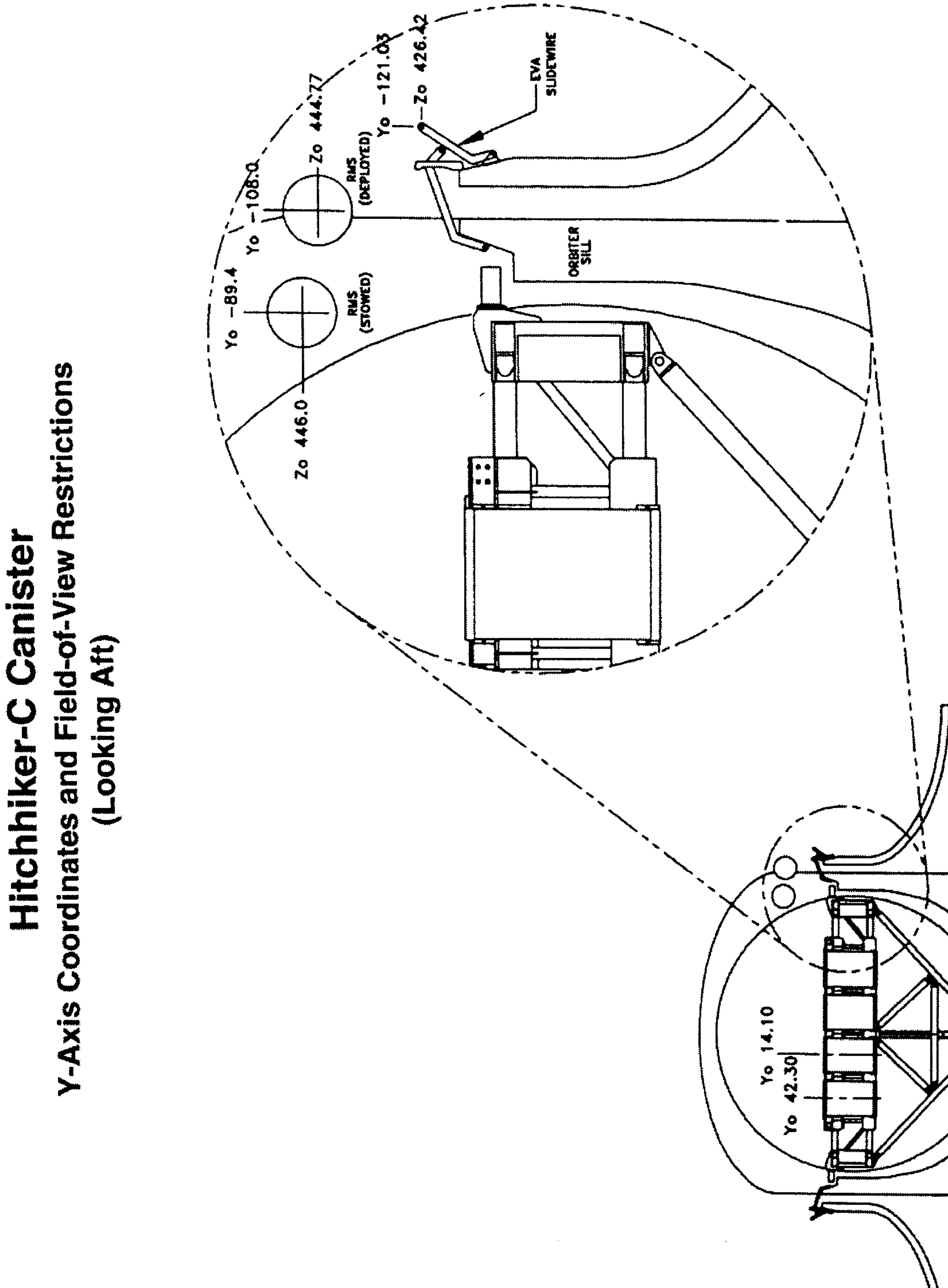


FIGURE 2.23 HITCHHIKER-C CANISTER

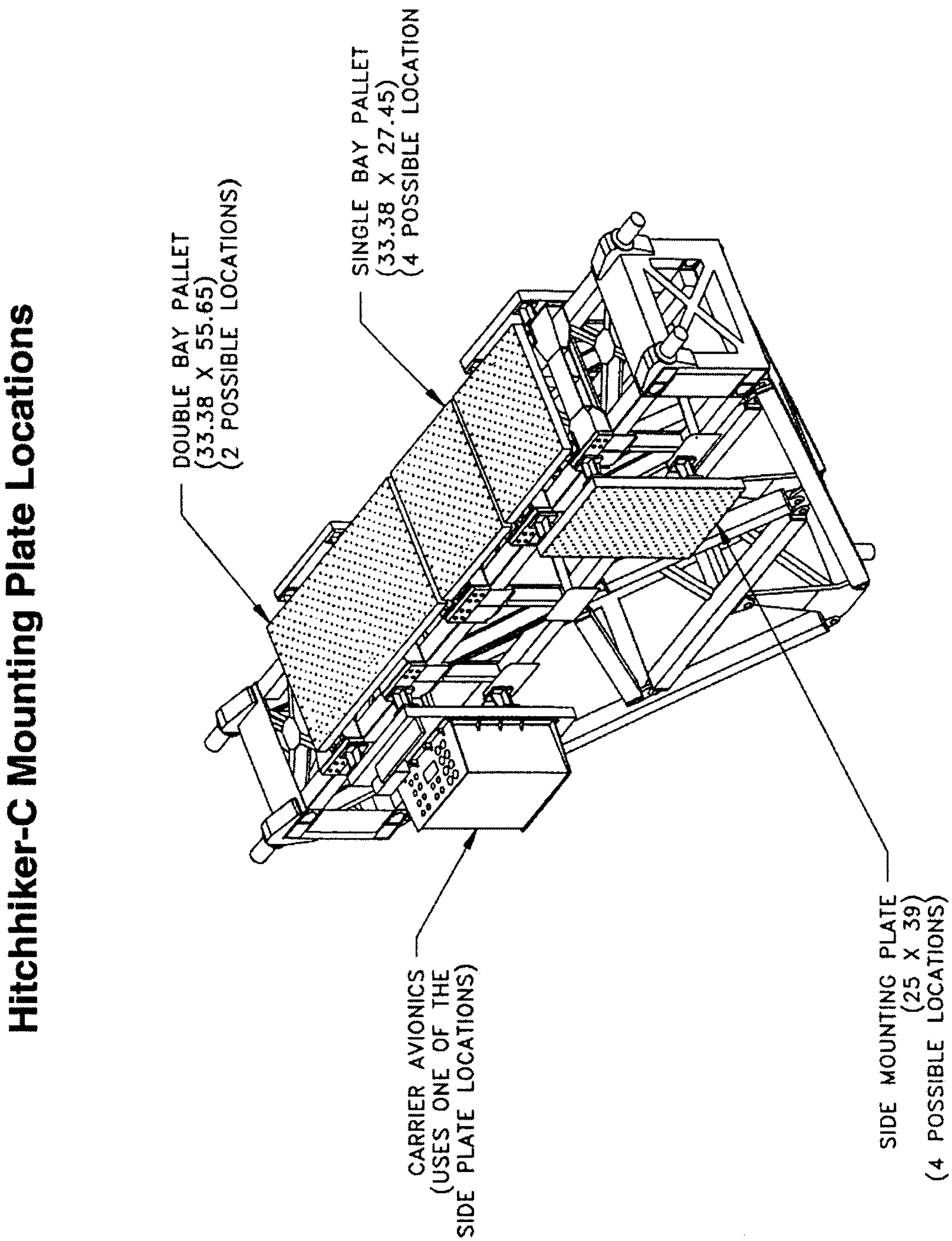


FIGURE 2.24 HITCHHIKER-C MOUNTING PLATE LOCATIONS

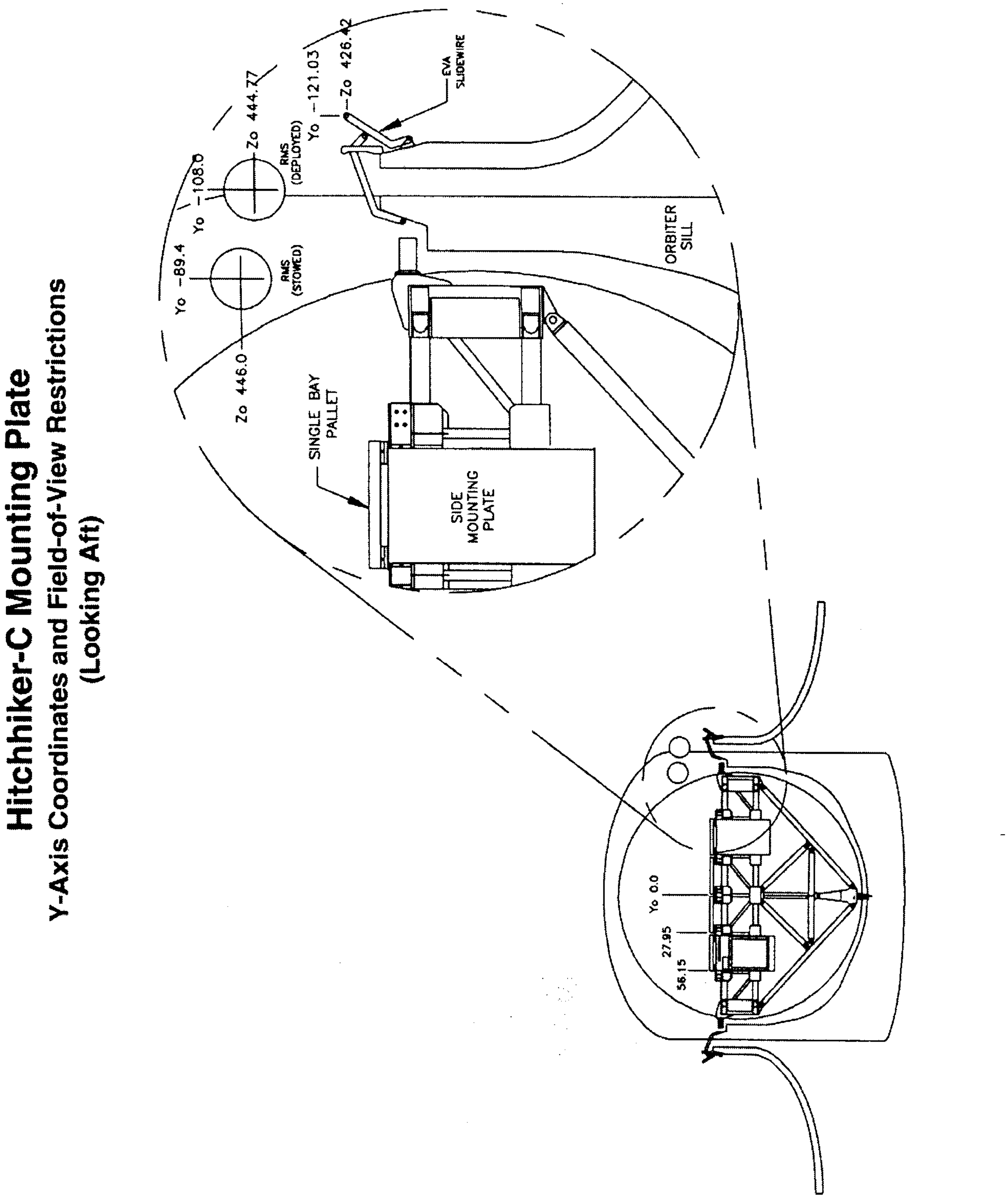


FIGURE 2.25 HITCHHIKER-C MOUNTING PLATE

2.1.4.5 HH-C Top Mounting Pallets

The HH-C top mounting pallets are also shown in Figure 2.24. Their field-of-view restrictions are shown in Figure 2.25. The small pallet is roughly 33" by 27". The large pallet is roughly 33" by 56". Both pallets can handle up to 600 pounds, provided the center of gravity of the experiment hardware is within the design envelopes as shown in Figure 2.26.

2.1.4.6 HH-C Direct Mounting

Large/heavy customer equipment which is not suitable for accommodation on the standard plates or canisters may be attached directly to existing HH MPE or may be attached to the structure by means of new customer-unique MPE, provided by GSFC as an optional service. Hardware mounting locations are shown in Figure 2.27. In either case, the customer's structural design must safely accommodate larger differential temperature changes between his/her equipment and the carrier. Proposals for direct mounting should be sent to the HH project for evaluation.

2.1.5 HH Side Mounting Plates

The HH side mounting plate is a generic plate combining the capabilities of the HH-S and HH-C side plates.

CG Envelope & Positions

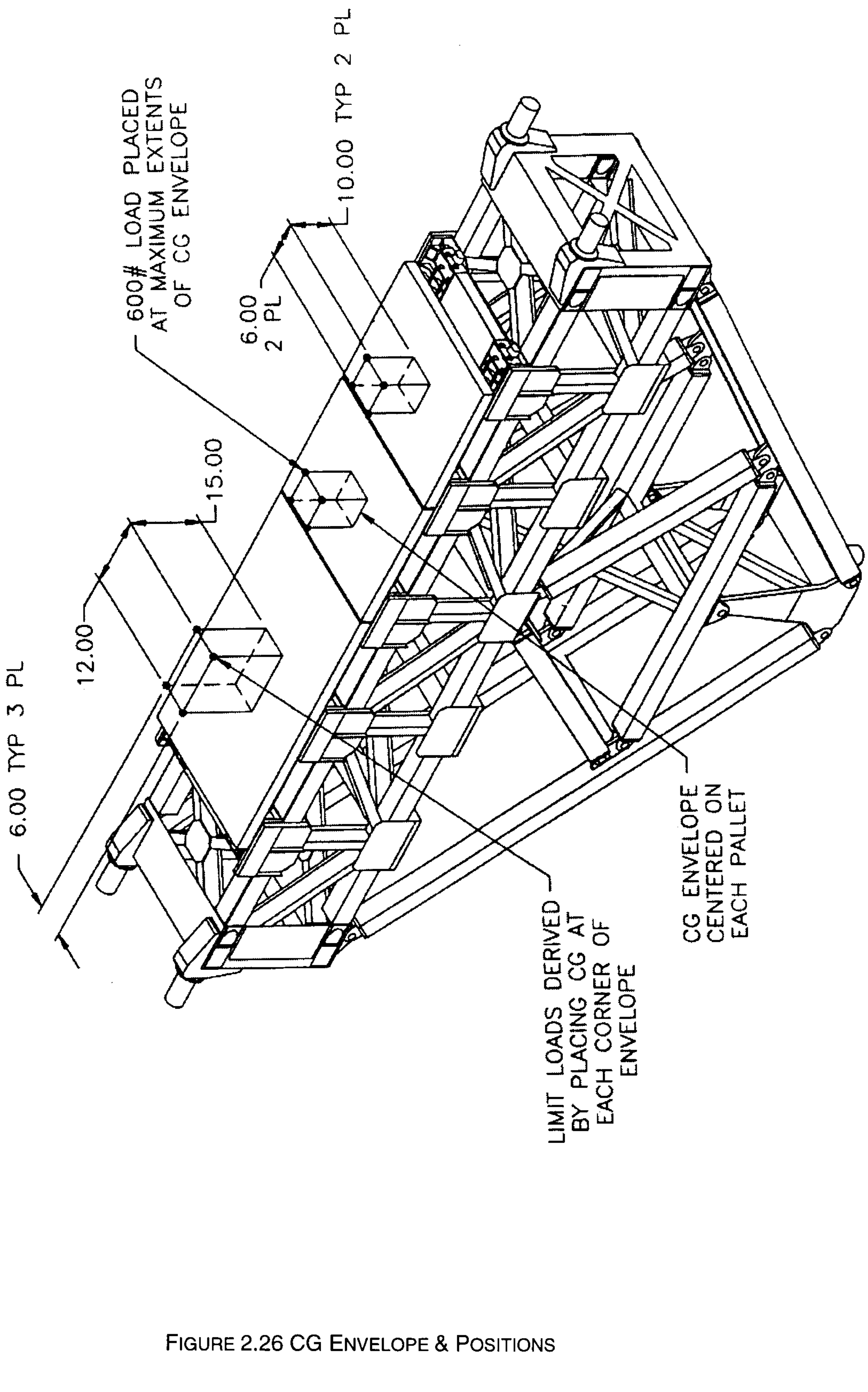
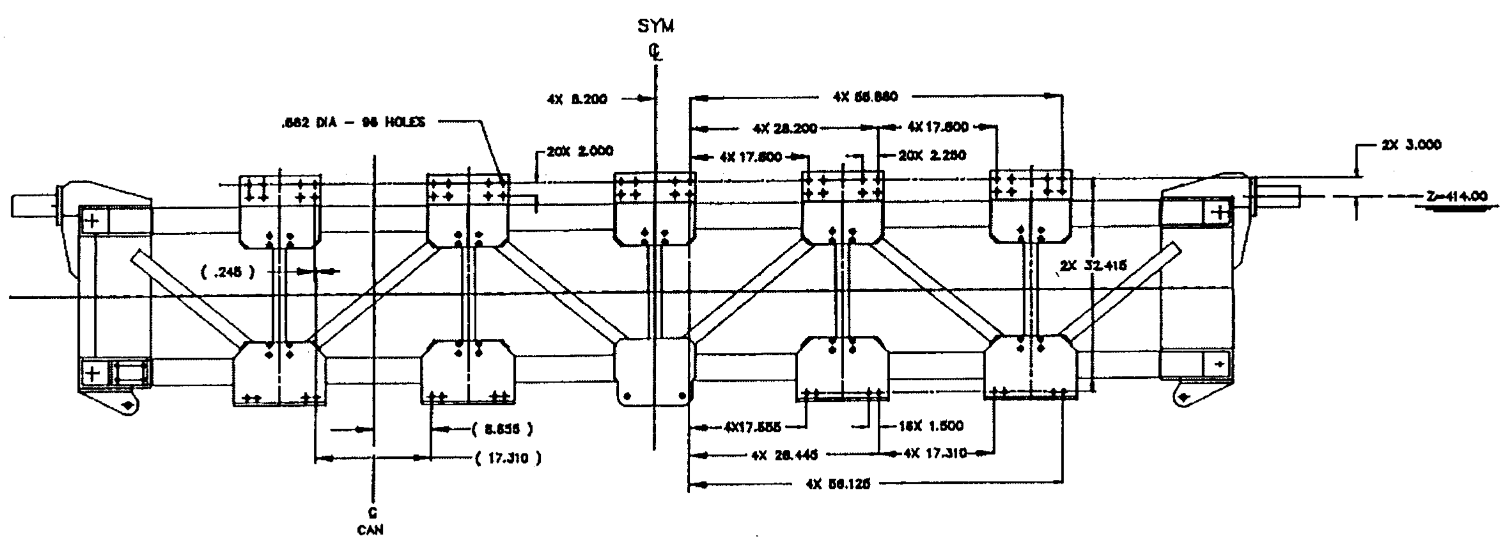


FIGURE 2.26 CG ENVELOPE & POSITIONS

Hitchhiker-C Experiment Mounting Interface
(Side Mount)



NOTE:

The X numbers (i.e., 4X, 20X, etc.) indicate the number of occurrences of this dimension over the entire structure, two halves both near side and far side.

FIGURE 2.27 HITCHHIKER-C EXPERIMENT MOUNTING INTERFACE

2.2 *Thermal Considerations*

2.2.1 Thermal Design Requirements

The Hitchhiker carrier and customer equipment relies primarily on a passive thermal design consisting of multilayer insulating blankets (MLI) and selected surface-finish applications. The MLI will be used to reduce energy losses and gains from the environment. Thermostatically controlled heaters will be used where tighter thermal control is needed, and passive radiators will be used to dump excess heat from instruments. This cold-bias design philosophy incorporates a low cost approach to maintaining temperature requirements throughout the HH payload.

The thermal design and analysis of each experiment is a customer responsibility. The customer shall determine all internal conduction, convection, and radiation within their experiment. They shall be responsible for the proper design and coupling of high power components. Reduced thermal models of the experiment and associated electronics are to be supplied to HH. Temperature limits as defined below shall also be provided for each node in the reduced thermal math model.

> Operating Temperature: The temperature at which a unit will successfully function and meet all specifications.
>
> Non-Operating Temperature: The temperature to which a unit may be exposed in a power OFF condition and if turned ON, will not be damaged. The unit does not have to meet its specification until it is within the operational temperature range.
>
> Survival Temperature: The temperature, if exceeded, at which the unit will suffer permanent damage.
>
> Safety Temperature: The temperature, if exceeded, at which the unit could potentially lead to catastrophic damage to the orbiter or injury to the crew members.

The customer shall also define any special temperature requirements, such as levels and gradients. Ground temperatures and humidity provided by the Orbiter and other ground processing locations at KSC are defined in ICD2-19001.

A list of the following external surface properties: area (size), thermal coatings, absorptivity (α), emissivity (ε), and reflectivity shall be provided. The customer will be responsible for obtaining approval from GSFC regarding any proposed thermal coatings not standard to HH. They shall also be responsible for providing heaters on the experiment provided hardware. The heater specification along with the predicted dissipation, duty cycle and HH bus usage shall be supplied to HH.

2.2.2 Thermal Safety Requirements

The customer must also be aware of all safety concerns of their payloads including that the experiment must be safe without services i.e. remain safe in the event of a power loss. Payloads must also be safe to land 40 minutes after payload bay door closure, occurring anytime during the mission. In addition to all safety analysis, all payloads must be able to fly in a bay-to-Earth attitude continuously and must be able to withstand 30 minute solar excursions and 90 minute deep space viewing at a minimum as stated in the Orbiter core ICD-2-19001. It is desirable to be able to withstand these extreme cases longer than the ICD requirement for manifesting reasons and longer runs are required for determining safety concerns such as the maximum design pressure (MDP) temperatures and battery limitations. The transient behavior of the experiment should be considered in all thermal analysis for the aforementioned cases.

2.2.3 Flammability Requirements for MLI Construction

Thermal control blankets are the most widely used materials in the payload bay that could be flammable. These blankets typically contain 12 to 40 layers of film (0.0005 to 0.002 inches in thickness) separated by some type of scrim cloth. Blanket materials are usually constructed of metal-coated polyethylene terephthalate or polyimide film, organic separator scrim, or beta cloth. Beta cloth and polyimides (at least 1.5 mil thick) are the only nonflammable materials.

Acceptable thermal control blankets are typically constructed as follows:

a. The outer layer is made of nonflammable material such as a polyimide film (at least 1.5 mil thick,) metal foil, or beta cloth.
b. Internal layers can be a combination of flammable films or scrims.
c. The innermost layer (adjacent to the outer surface of the payload) is also made of nonflammable materials.
d. Edges are hemmed or suitably finished so that the inner flammable layers are protected.

Reference: "Flammability Configuration Analysis for Spacecraft Applications" document NSTS 22648 dated October 1988.

2.2.4 Thermal System Design for a HH Canister

There are presently four options available to HH canister customers:

1. Fully insulated canister
2. Insulated canister without upper insulating end cap.
3. Uninsulated canister with lower insulating end cap.
4. Opening lid canister (uses insulated canister).

The first three options pertain to a sealed HH canister, while the fourth refers to the opening lid canister. The three canister insulation options for the sealed canister are intended to offer a wide range of heat rejection capabilities depending on customer requirements. GSFC provides all exterior thermal insulation and coatings for canisters except for the top surface of an HMDA customer payload. The temperatures listed for each orientation are approximate, and may vary somewhat (approx. +/- 10°C) depending on the Shuttle orbital attitude and beta angle (angle between the Shuttle orbit plane and the sun).

The first option, a fully insulated canister, would be the best choice for customers with relatively low power requirements. This option minimizes heater power needed to maintain operational temperature levels at cold Orbiter orientations. It does not, however, allow for large power dissipations on a continuous basis. Average steady-state canister upper endplate temperatures for various Shuttle attitudes and customer payload power levels is given in Figure 2.28. The temperatures from Figure 2.28 are representative of internal experiment temperature levels. The corresponding Orbiter attitudes are defined in Figure 2.29.

Option 2 offers an increased heat rejection capability over option 1, as shown in Figure 2.30. The canister top plate exterior surface is coated with silver teflon (α = . 10, ϵ =.75) and acts as a radiator while the rest of the canister is insulated. Increased heater power, however, is required in order to maintain minimum temperature levels in cold Orbiter orientations. .

Option 3 is available to customers requiring a large heat rejection capability. In this case, the side walls of the canister are painted white (α =.24, ϵ = .86) and are allowed to radiate directly to the Shuttle bay and space. The average upper endplate temperature for various conditions is given in Figure 2.31. Power levels higher than those shown can be accommodated for short time periods depending on customer thermal design. However, large temperature gradients can be realized along with high power levels. Therefore, special attention should be given to the thermal design if Option 3 is selected. Also, large heater power levels are required to maintain minimum temperature levels even in the Earth viewing case if the experiment is operating at low levels. Transient response times are reduced as well.

Option 4 refers to the opening-lid canister. When the lid is closed, the canister thermal behavior is approximately the same as that of the fully insulated canister (Option 1). When open, thermal behavior is heavily dependent on the customer payload thermal design, especially the exposed upper portion of the instrument. It is suggested that customers using this option pay particular attention to their thermal design, due to the increased complexity resulting from the opening lid. Thermal information for customers with opening-lids can be found in "Thermal Design Guide for Get Away Special/Motorized Door Assembly Users."

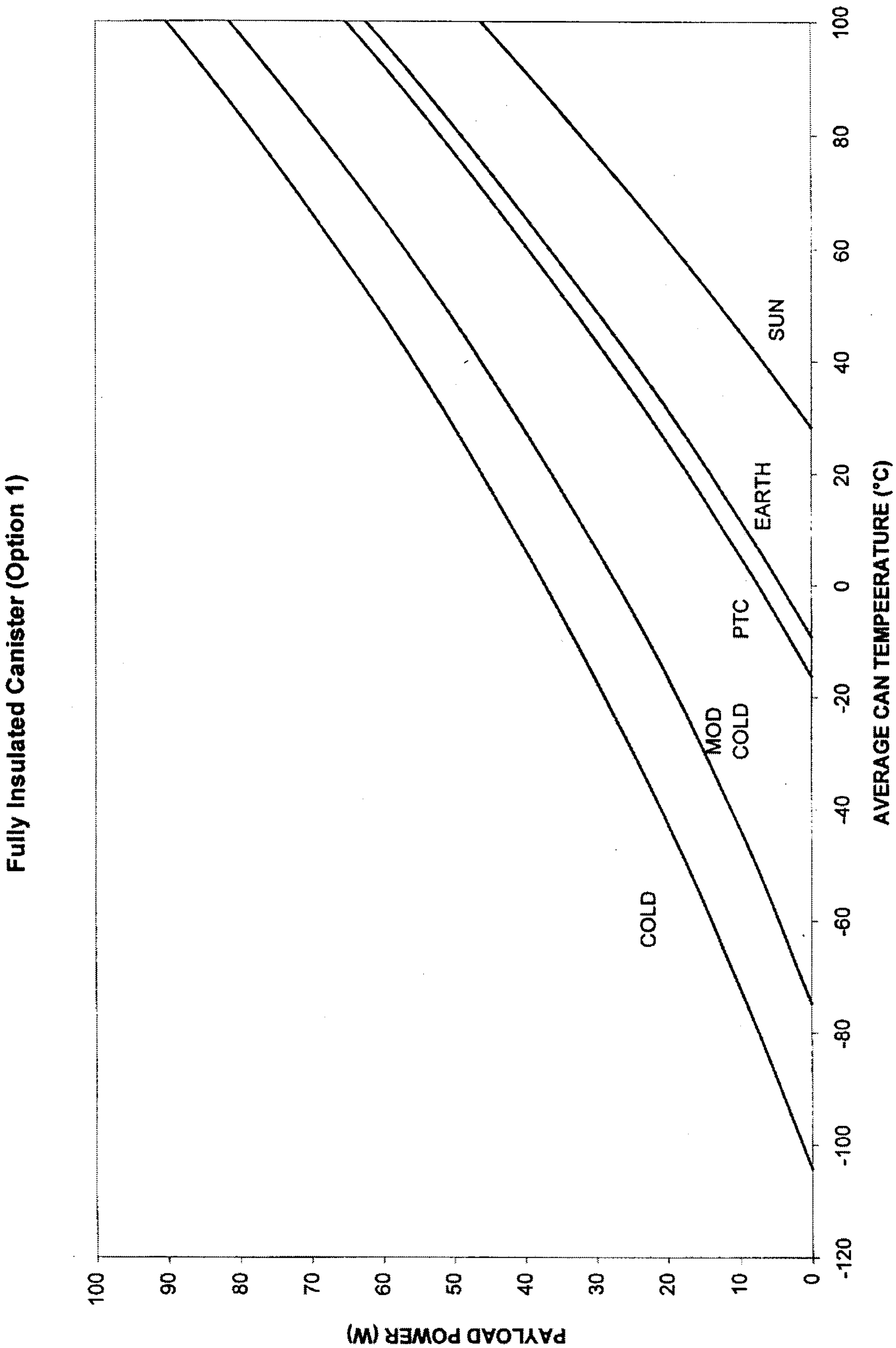


FIGURE 2.28 FULLY INSULATED CANISTER (OPTION1)

Typical Orbital Thermal Attitudes

(61% Sun, B=35°, and Altitude = 150 n.mi. (278km.)

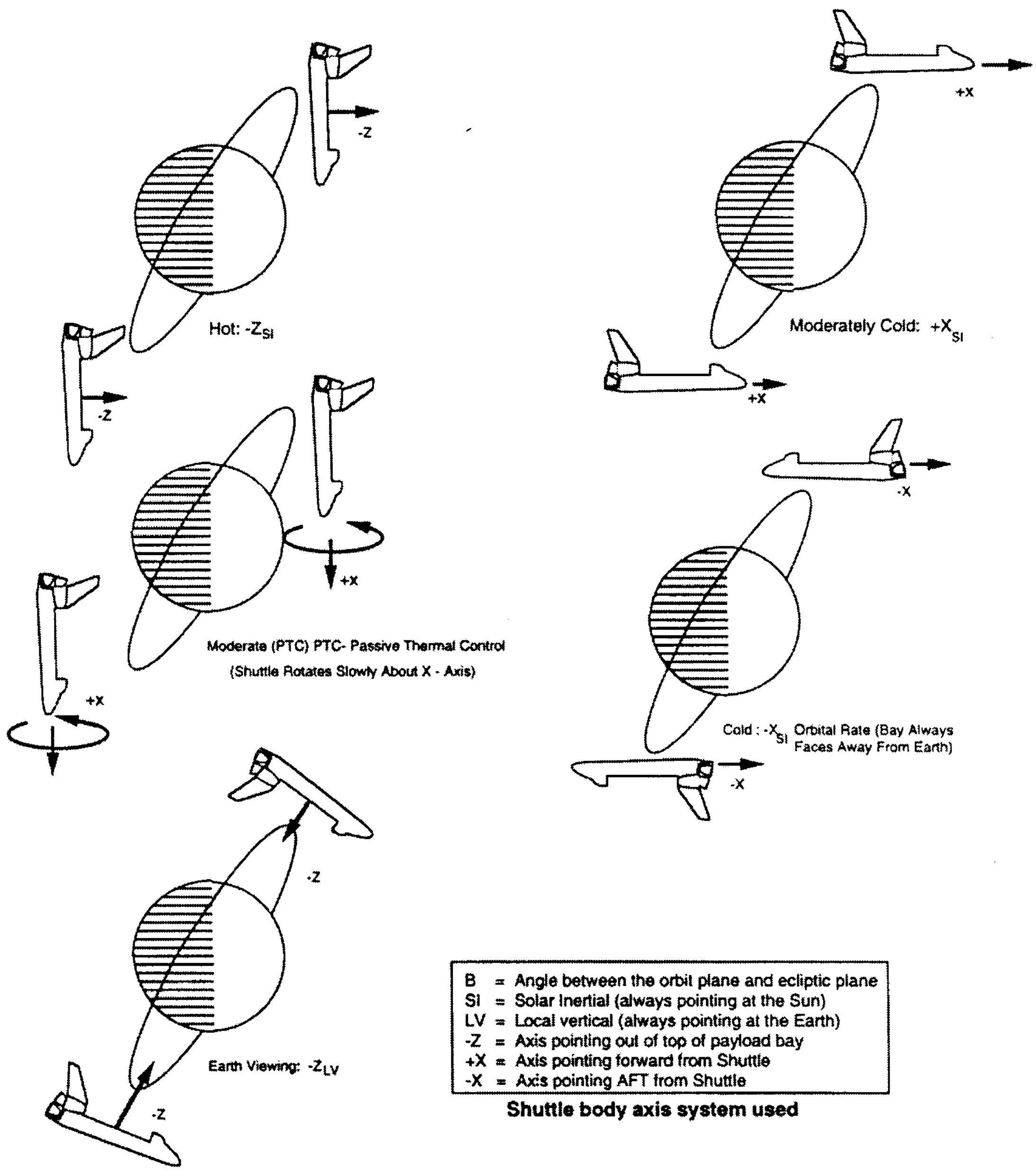


FIGURE 2.29 TYPICAL ORBITAL THERMAL ATTITUDES

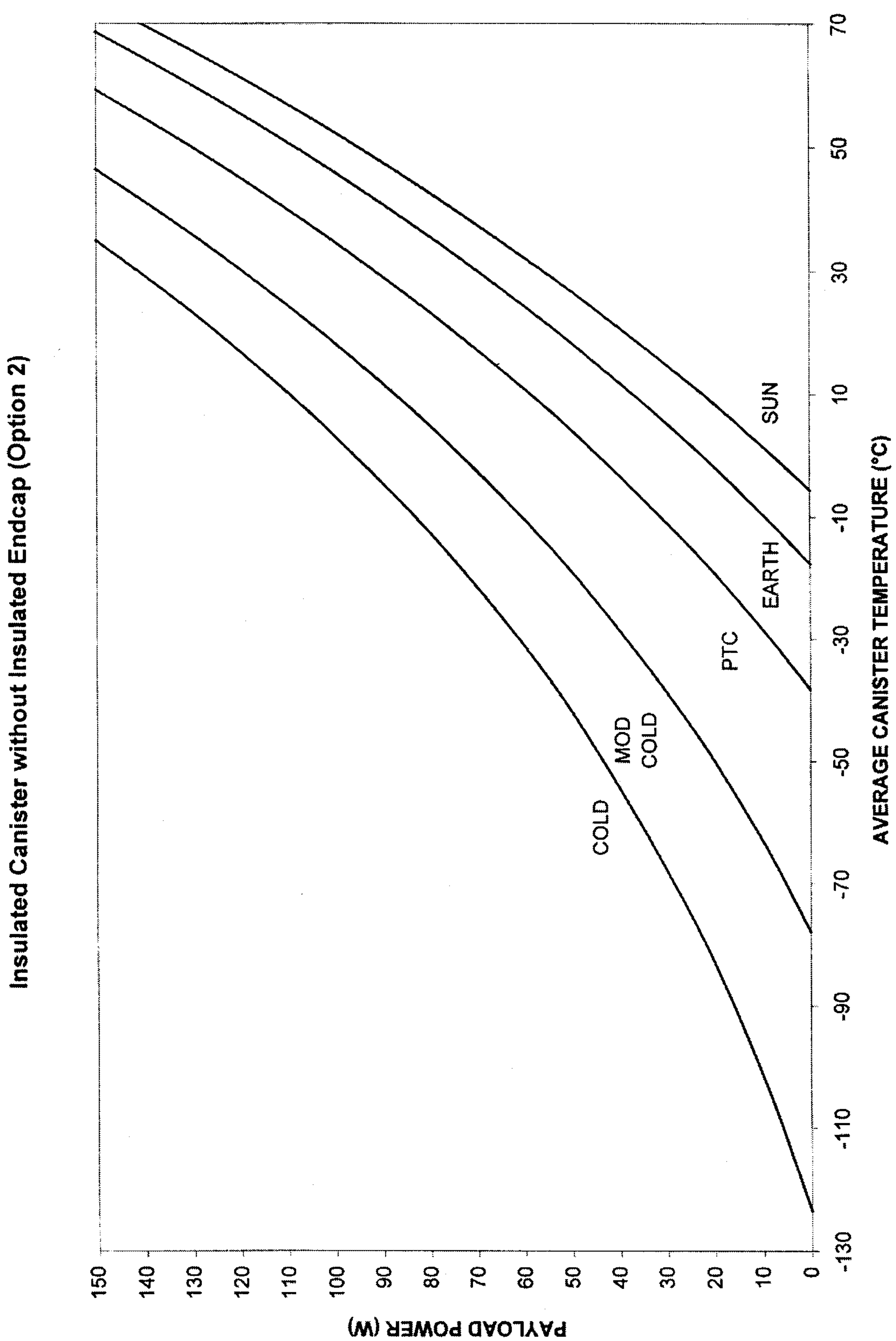


FIGURE 2.30 INSULATED CANISTER WITHOUT INSULATED ENDCAP (OPTION 2)

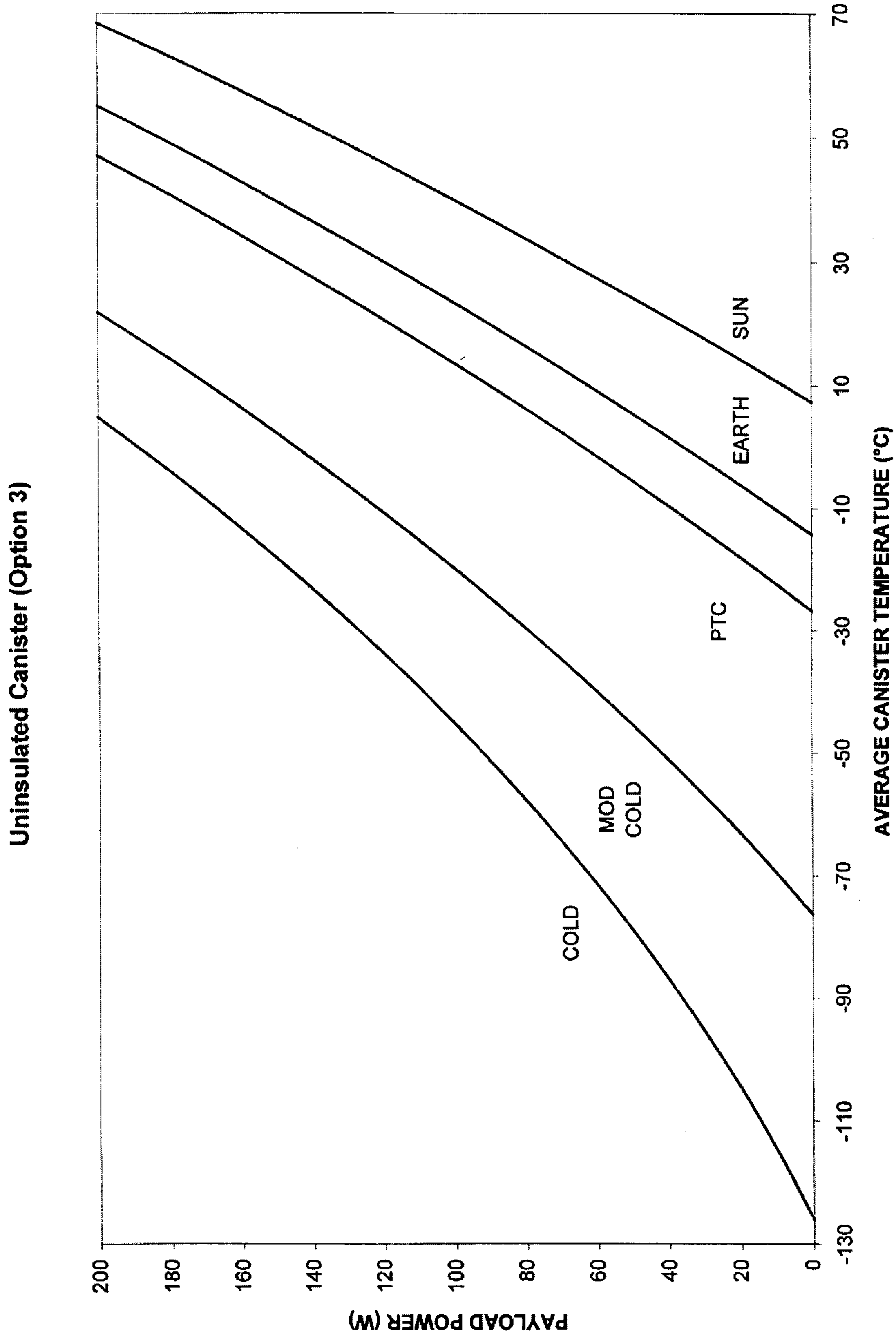


FIGURE 2.31 UNINSULATED CANISTER (OPTION 3)

Experimental data was obtained from the GAS Flight Verification Payload (FVP) on the flight of STS-3. Table 2.2 lists the steady-state temperature predictions and results for both hot and cold cases for the inside portion of the FVP. The experimental results are averages of thermistors or nodes at the indicated locations. The flight results listed are the hottest and coldest levels actually attained. They are not, however, the worst possible hot or cold case temperatures since steady-state conditions were not attained.

TABLE 2.2 CONTAINER AND PAYLOAD FLIGHT STEADY STATE THERMAL RESULTS

(Temperatures In °C) From Gas Verification Payload

	HOT CASE		COLD CASE	
LOCATION	PREDICTED	ACTUAL	PREDICTED	ACTUAL
Top Plate	48.0	32.0	-20.6	-2.5
Container Sides	49.2	32.0	-19.1	-3.0
Bottom Plate	49.9	34.0	-19.5	-3.0
Battery	52.3	31.0	-5.7	+1.0
Tape Recorder	52.9	35.0	0.0	+4.0
Power	13.0W	13.0W	34.0W	13.0W

Note: Actual flight thermal levels did not reach steady-state conditions. The levels are the maximum and minimum temperatures that were reached.

Table 2.3 shows external environmental thermal levels for steady-state conditions of the GAS container. It includes both predicted and actual flight thermal levels. Steady-state temperatures were not attained for the tail-to-sun, extreme cold case, which, therefore, is omitted from the table. The two predicted values for the adapter beam hot case correspond to two absorptivity values. The higher absorptivity value gives a better hot case correlation.

TABLE 2.3 GAS CONTAINER EXTERNAL THERMAL LEVELS AT STEADY STATE

	PREDICTIONS °C	FLIGHT °C
Adapter Beam (Hot-Bay to Sun)	+37 to +46	+45 to +50
Adapter Beam (Cold-Nose to Sun)	-78	-40
Bottom Cover (Hot-Bay to Sun)	+63	+63 to +65
Bottom Cover (Cold-Nose to Sun)	-76	-45 to -50
Top Cover (Bracket) (Hot-Bay to Sun)	+31	+25 to +35
Top Cover (Bracket) (Cold-Nose to Sun)	-73	-47 to -52

2.2.5 Thermal System Design for Pallet and Plate Mounting

The customer is responsible for the thermal design of a plate-mounted experiment system. This design will encompass the plate and its attachments to the GAS beam and Orbiter or to the HH bridge. Normally, in order to avoid problems with thermal/mechanical stress, a customer will want to provide good thermal conduction between his/her equipment and the HH mounting plate. On HH-S, the mounting plate has poor thermal conduction to the GAS beam. On HH-C, mounting plates are thermally isolated from the cross bay structure by means of special hardware which allows for thermal expansion. The HH-S GAS beam is attached to the Orbiter with hardware that also provides thermal isolation and allows for expansion.

GSFC will supply thermal model data on the HH plates and their attachments to customers. GSFC will also supply insulation for the backs of plates and white painted regions to cover the unoccupied front surface of plates. GSFC will supply a standard heater system on the back of the HH-S and HH-C small plate consisting of 104-watt heater and three thermistors. For the top of the bridge single and double bay pallets, GSFC will also supply 104 watts of heater power. (Thermostats on these plates open at 12 +/- 3 deg C and close at 6 +/- 3 deg C.) The customer may use this system by providing a cable to connect the thermal system to power from his customer port.

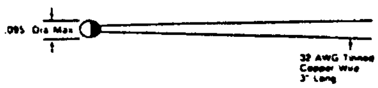
2.2.6 Thermistors

Three thermistors are available for each plate and pallet experiment. Opening can experiments have no thermistors except for one mounted on the lower endplate. Sealed canister experiments allow one thermistor to be used at the customer's discretion and one will be mounted on the lower end plate. Additional thermistors may be available through negotiation with the HH project.

These thermistors, Yellow Springs Instrument Company (YSI) 44006 type or equivalent (see the manufacturer's specification sheet on the following page), are supplied by the HH Project for connection to appropriate pins on J2, as outlined in Tables 2.4 and 2.5. This interface configuration allows monitoring of up to three temperatures when customer payload power is on or off. The thermistor interface between customer and carrier is shown in Figure 2.33.

YSI 44006

RESISTANCE 10,000 OHMS @25°C



RESISTANCE VERSUS TEMPERATURE —80° to +150°C

TEMP°C	RES	TEMP°C	RES	TEMP°C	RES	TEMP°C	RES	TEMP°C	RES	TEMP°C	RES	TEMP°C	RES	TEMP°C	RES
−80	3558K	−50	441.3K	−20	78.91K	+10	18.79K	+40	5592	+70	1990	+100	816.8	+130	376.4
79	3296K	49	414.5K	19	74.91K	11	17.98K	41	5389	71	1928	101	794.6	131	367.4
78	3055K	48	389.4K	18	71.13K	12	17.22K	42	5193	72	1868	102	773.1	132	358.7
77	2833K	47	366.0K	17	67.57K	13	16.49K	43	5006	73	1810	103	752.3	133	350.3
76	2629K	46	344.1K	16	64.20K	14	15.79K	44	4827	74	1754	104	732.1	134	342.0
75	2440K	45	323.7K	15	61.02K	15	15.13K	45	4655	75	1700	105	712.6	135	334.0
74	2266K	44	304.6K	14	58.01K	16	14.50K	46	4489	76	1648	106	693.6	136	326.3
73	2106K	43	286.7K	13	55.17K	17	13.90K	47	4331	77	1598	107	675.3	137	318.7
72	1957K	42	270.0K	12	52.48K	18	13.33K	48	4179	78	1549	108	657.5	138	311.3
71	1821K	41	254.4K	11	49.94K	19	12.79K	49	4033	79	1503	109	640.3	139	304.2
−70	1694K	−40	239.8K	−10	47.54K	+20	12.26K	+50	3893	+80	1458	+110	623.5	+140	297.2
69	1577K	39	226.0K	9	45.27K	21	11.77K	51	3758	81	1414	111	607.3	141	290.4
68	1469K	38	213.2K	8	43.11K	22	11.29K	52	3629	82	1372	112	591.6	142	283.8
67	1369K	37	201.1K	7	41.07K	23	10.84K	53	3504	83	1332	113	576.4	143	277.4
66	1276K	36	189.8K	6	39.14K	24	10.41K	54	3385	84	1293	114	561.6	144	271.2
65	1190K	35	179.2K	5	37.31K	25	10.00K	55	3270	85	1255	115	547.3	145	265.1
64	1111K	34	169.3K	4	35.57K	26	9605	56	3160	86	1218	116	533.4	146	259.2
63	1037K	33	160.0K	3	33.93K	27	9227	57	3054	87	1183	117	519.9	147	253.4
62	968.4K	32	151.2K	2	32.37K	28	8867	58	2952	88	1149	118	506.8	148	247.8
61	904.9K	31	143.0K	− 1	30.89K	29	8523	59	2854	89	1116	119	494.1	149	242.3
−60	845.9K	−30	135.2K	0	29.49K	+30	8194	+60	2760	+90	1084	+120	481.8	+150	237.0
59	791.1K	29	127.9K	+ 1	28.15K	31	7880	61	2669	91	1053	121	469.8		
58	740.2K	28	121.1K	2	26.89K	32	7579	62	2582	92	1023	122	458.2		
57	692.8K	27	114.6K	3	25.69K	33	7291	63	2497	93	994.2	123	446.9		
56	648.8K	26	108.6K	4	24.55K	34	7016	64	2417	94	966.3	124	435.9		
55	607.8K	25	102.9K	5	23.46K	35	6752	65	2339	95	939.3	125	425.3		
54	569.6K	24	97.49K	6	22.43K	36	6500	66	2264	96	913.2	126	414.9		
53	534.1K	23	92.43K	7	21.45K	37	6258	67	2191	97	887.9	127	404.9		
52	501.0K	22	87.66K	8	20.52K	38	6026	68	2122	98	863.4	128	395.1		
51	470.1K	21	83.16K	9	19.63K	39	5805	69	2056	99	839.7	129	385.6		

Interchangeability: ±0.2°C (See Tolerance Curves).

Max. Operating Temp: 150°C (300°F).

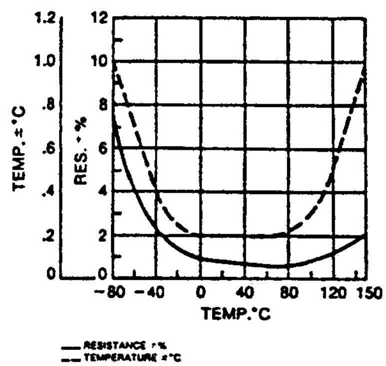
Time Constant, Max: 1 sec. in well stirred oil. 10 sec. in still air. Time constant is the time required for a thermistor to indicate 63% of a newly impressed temperature.

Dissipation Constant, Min: 8mW/°C in well stirred oil, 1mW/°C in still air. Dissipation constant is the power in milliwatts to raise a thermistor 1°C above surrounding temperature.

Color Code: Black epoxy body, blue end.

Storage Temperature: -80° to +120°C (-112° to +250°F).

Tolerance Curves: The following curves indicate conformance to standard resistance temperature values as a % of resistance, and as a maximum interchangeability error expressed as temperature.



WARNING

Use heat sinks when soldering or welding to thermistor leads.

FIGURE 2.32 YSI PRECISION THERMISTOR

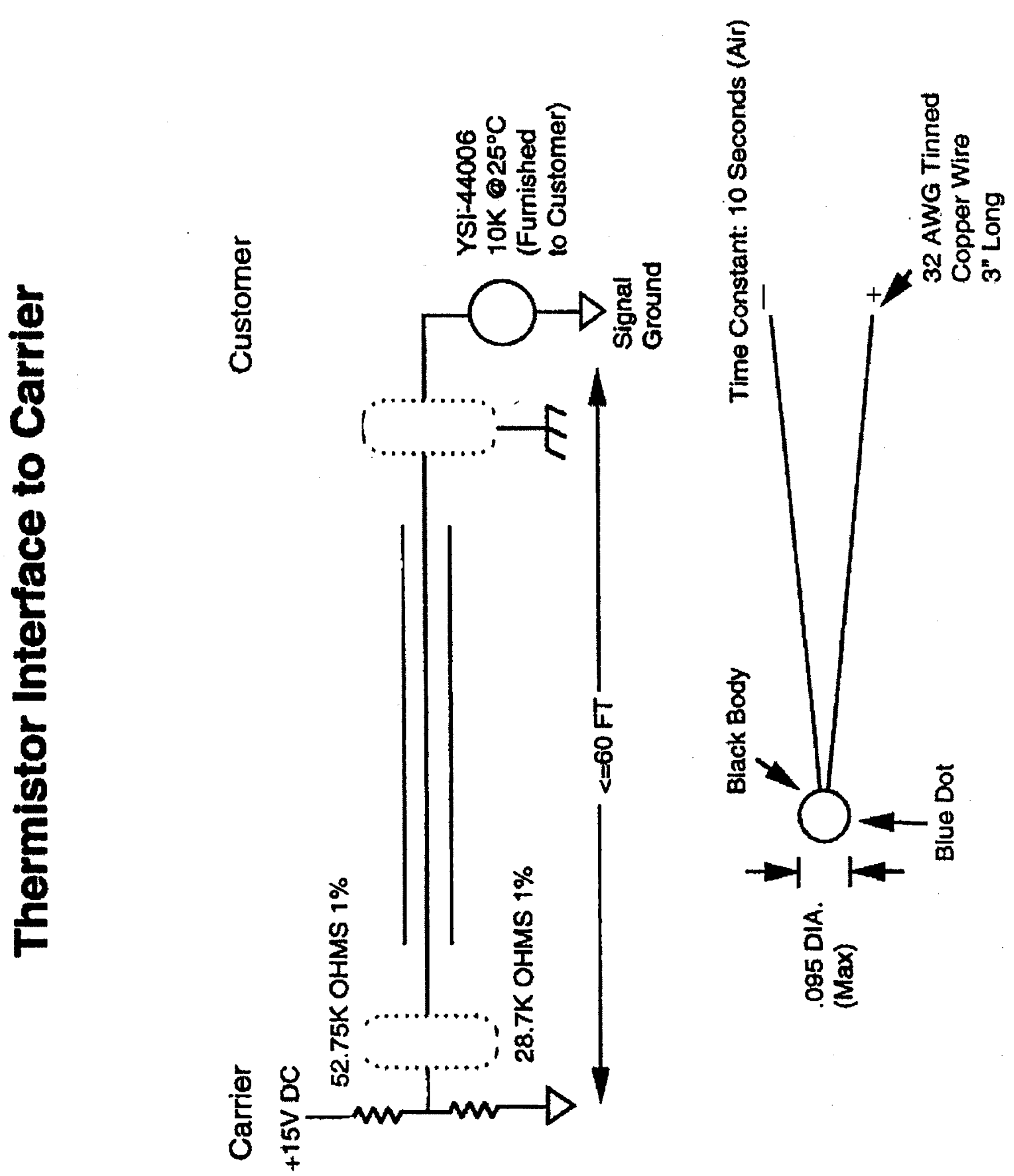


FIGURE 2.33 THERMISTOR INTERFACE TO CARRIER

2.3 Electrical/Power Support Systems

2.3.1 Electrical Design

The electrical interfaces for plate mount and canister customers differ slightly. Figure 2.34 and Table 2.4 give plate mounting details. Figure 2.35, 2.36, and Table 2.5 provide details on the canister mount. Figure 2.36 shows the Motorized Door Canister with the control and monitoring interface. Electrical designs interfaces are governed by ICD-2-19001. The electrical characteristics of the thermistors is defined in Section 2.2.6.

2.3.2 Power Characteristics

Each of the two 12 gauge 28V power lines is protected by a 20A fuse (vacuum derated to 10A), per figure 2.37. Customers must provide consistent wiring and fusing within their payloads. Smaller gauge wire for power service shall require an appropriately down-sized fuse to provide circuit protection. Table 2.6 shows acceptable wire and fuse sizes.

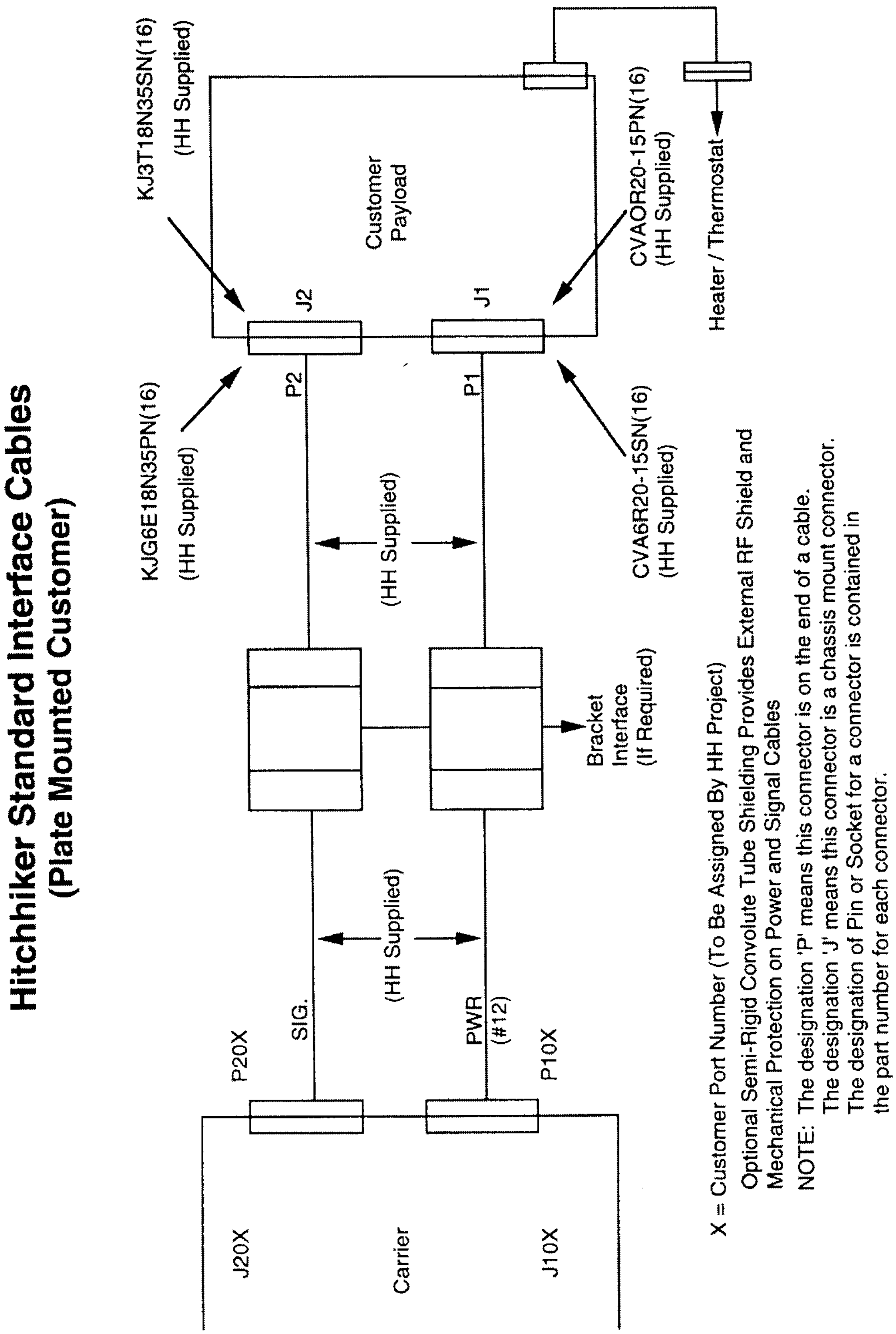


FIGURE 2.34 HITCHHIKER STANDARD INTERFACE CABLES

TABLE 2.4 PLATE ELECTRICAL INTERFACE CONNECTORS

ID	PIN (Note 3)	Type (Note 2)	Function
Power Connector J1: (Note 4)			
+28A	A	C	+28V Power Circuit A
RETA	B	C	Power Return (Note 1)
+28B	C	C	+28V Power Circuit B
RETB	D	C	Power Return (Note 1)
+28HTR	E	B	+28V Heater Power
RETH	F	B	Heater Power Return (Note 1)
FRMGND	G	B	Frame Ground
Signal Connector J2: (Note 4)			
PCMAD	1	A	PCM Analog Data
PCMINDX	41	A	PCM Index Pulse
SIGGND	2	A	Signal Ground
PCMCLK	42	A	PCM Bit Rate Clock (Note 5)
PCMENA	32	A	Serial Digital Enable A (Note 5)
PCMENB	33	A	Serial Digital Enable B (Note 5)
PCMDATA	3	A	Serial Digital Data A (Note 5)
PCMDATB	8	A	Serial Digital Data B (Note 5)
THER1	14	A	Thermistor 1
THER2	15	A	Thermistor 2
THER3	16	A	Thermistor 3
SHIELD	6	A	Shield For Command And Data Signals
RD+	21	A	Receive Data Async + From SPOC
RD-	22	A	Receive Data Async - From SPOC
SD+	23	A	Send Data Async + To SPOC
SD-	24	A	Send Data Async - To SPOC
BLCMD1	17	A	Bi-Level/Pulse Command 1
BLCMD2	18	A	Bi-Level/Pulse Command 2
BLCMD3	19	A	Bi-Level/Pulse Command 3
BLCMD4	20	A	Bi-Level/Pulse Command 4
SCMDCLK	10	A	Serial Command Clock (Note 5)
SCMDENV	11	A	Serial Command Envelope (Note 5)
SCMDDAT	12	A	Serial Command Data (Note 5)
METMIN	40	A	MET/MET One Minute Pulse
IRIGMET+	30	A	IRIG-B MET (MET) +
IRIGMET-	31	A	IRIG-B MET (MET) -
FRMGND	49	A	Frame Ground
KUMRCLK+	34	A	Customer Generated MR Clock +
KUMRCLK-	35	A	MR Clock -

ID	Pin (Note 3)	Type (Note 2)	Function
KUMRDAT+	43	A	Customer Generated MR Data +
KUMRDAT-	44	A	MR Data -
KUMRSHLD	25	A	Shield For KU Signals
UNDTSP1+	61	D	Undedicated TSP 1 + (Optional Video +)
UNDTSP1-	66	D	Undedicated TSP 1 - (Optional Video -)
UNDTSPS1	54	A	Shield For Undedicated TSP 1
UNDTSP2+	62	D	Undedicated TSP 2 +
UNDTSP2-	63	D	Undedicated TSP 2 -
UNDTSPS2	55	A	Shield For Undedicated TSP 2
UNDTSP3+	56	D	Undedicated TSP 3 +
UNDTSP3-	57	D	Undedicated TSP 3 -
UNDTSPS3	48	A	Shield For UNDTSP3
UND4	58	A	Undedicated 4
UND5	59	A	Undedicated 5
UND6	60	A	Undedicated 6
UND7	64	A	Undedicated 7
UND8	65	A	Undedicated 8
UNDS	53	A	Shield For Undedicated 4-8
MDAOC	52	A	Reserved
MDASTP	51	A	Reserved

Note 1: Power Return Pins B, D And F May Be Connected Together Within Payload.

Note 2: Wire Type Designations:

A 22 GA
B 16 GA
C 12 GA
D 26 GA

Note 3: Customer Will Make No Connections To Unused Pins

Note 4: The Designations "J1" And "J2" In This Table Indicate The Pin Out For A Chassis Mount Connector Mounted To A Particular Scientific Experiment. The Hh-Provided Connecting Cable Will Be Terminated In Connectors With A Designation Of "P1" And "P2" But Will Have The Identical Pin-Out As Shown In This Table.

Note 5: These services are no longer available/offered.

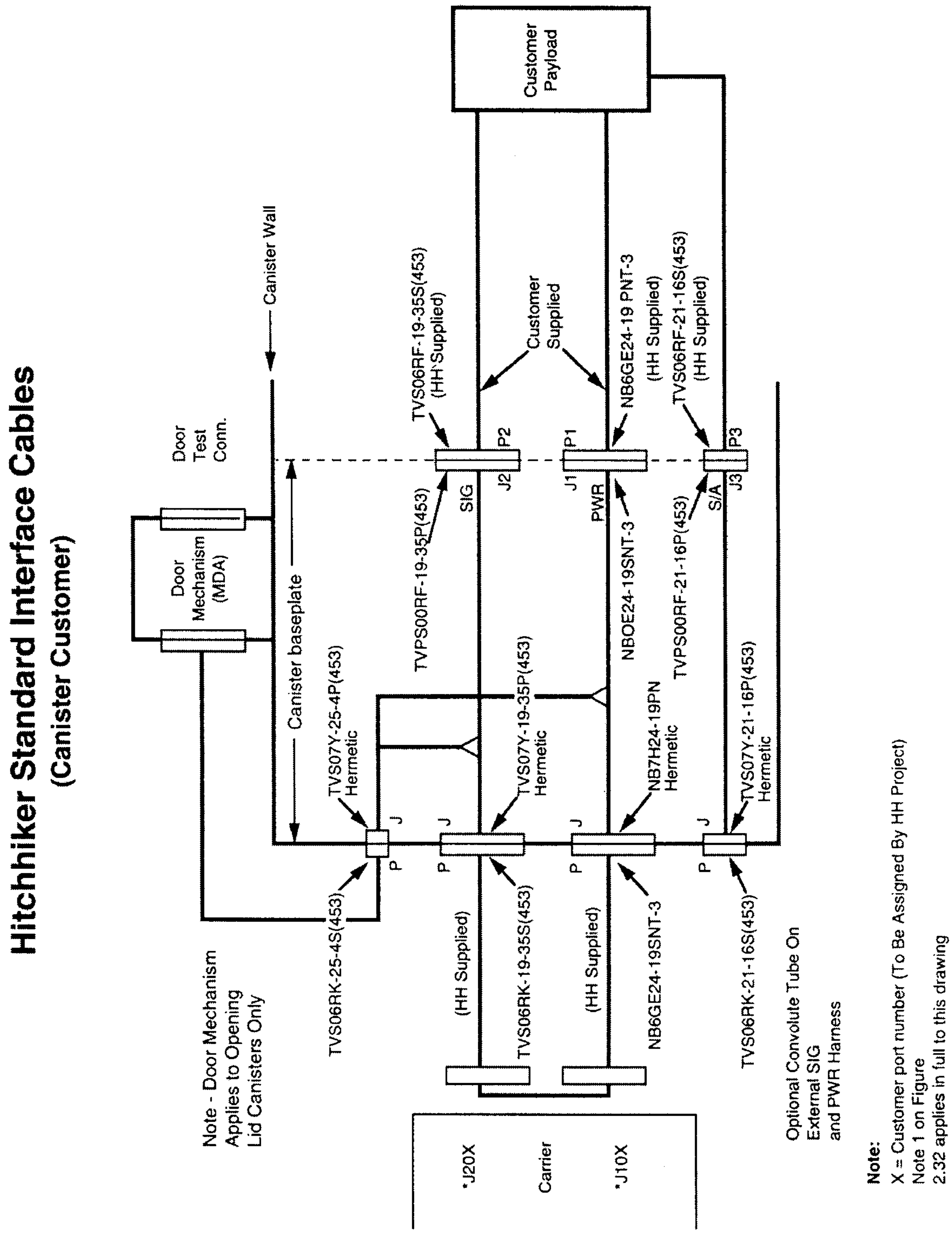


FIGURE 2.35 HITCHHIKER STANDARD INTERFACE CABLES

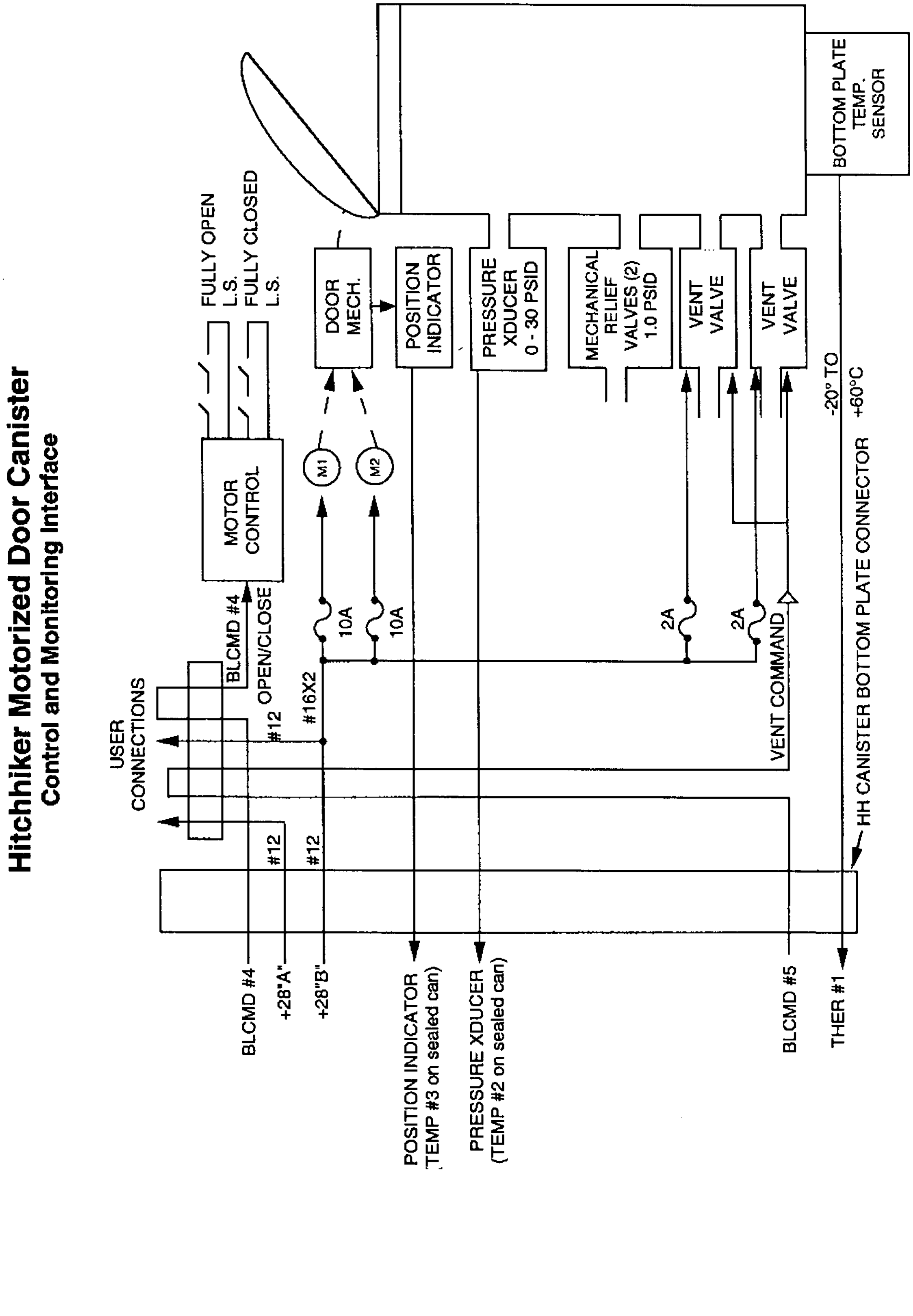


FIGURE 2.36 HITCHHIKER MOTORIZED DOOR CANISTER

TABLE 2.5 CANISTER ELECTRICAL INTERFACE CONNECTORS

ID	Pin(Note 3)	Type(Note 2)	Function
Power Connector P1:			
+28A	A	C	+28V Power Circuit A
RETA	B	C	Power Return (Note 1)
+28B	C	C	+28V Power Circuit B (Note 5)
RETB	D	C	Power Return (Note 1)
+28HTR	E	B	+ 28V Heater Power
RETH	F	B	Heater Power Return (Note 1)
FRMGND	G	B	Frame Ground
Signal Connector P2:(Note 4)			
PCMAD	1	A	PCM Analog Data
PCMINDX	41	A	PCM Index Pulse
SIGGND	2	A	Signal Ground
PCMCLK	42	A	PCM Bit Rate Clock (Note 11)
PCMENA	32	A	Serial Digital Enable A (Note 11)
PCMENB	33	A	Serial Digital Enable B (Note 11)
PCMDATA	3	A	Serial Digital Data A (Note 11)
PCMDATB	8	A	Serial Digital Data B (Note 11)
THER1	14	A	Thermistor 1 (Not Wired To PLD) (Note 6)
THER2	15	A	Canister Pressure (Not Wired To PLD)
THER3	16	A	MDA Door Position 0-5 V (Note 7)
SHIELD	6	A	Shield For Command And Data Signals
RD+	21	A	Receive Data Async + From SPOC
RD-	22	A	Receive Data Async - From SPOC
SD+	23	A	Send Data Async + To SPOC
SD-	24	A	Send Data Async - To SPOC
BLCMD1	17	A	Bi-level/Pulse Command 1
BLCMD2	18	A	Bi-level/Pulse Command 2
BLCMD3	19	A	Bi-Level/Pulse Command 3
BLCMD4	20	A	Bi-level Cmd 4/Open Close MDALID
SCMDCLK	10	A	Serial Command Clock (Note 11)
SCMDENV	11	A	Serial Command Envelope (Note 11)
SCMDDAT	12	A	Serial Command Data (Note 11)
GMTMIN	40	A	GMT/MET One-Minute Pulse
IRIGGMT+	30	A	IRIG-B GMT (MET) +
IRIGGMT-	31	A	IRIG-B GMT (MET)-
FRMGND	49	A	FRAME GROUND
KUMRCLK+	34	A	Customer-Generated MR Clock +
KUMRCLK-	35	A	MR Clock -
KUMRDAT+	43	A	Customer-Generated MR Data +
KUMRDAT-	44	A	MR Data -
KUMRSHLD	25	A	Shield For Ku Signals
UNDTSP1+	61	D	Undedicated TSP 1 + (Optional Video +)
UNDTSP1-	66	D	Undedicated TSP 1 - (Optional Video -)
UNDTSPS1	54	A	Shield For Undedicated TSP 1
UNDTSP2+	62	D	Undedicated TSP 2 +
UNDTSP2-	63	D	Undedicated TSP -
UNDTSPS2	55	A	Shield For Undedicated TSP 2

TABLE 2.5 CONTINUED

ID	Pin(Note 3)	Type(Note 2)	Function
UNDTSP3+	56	A	Undedicated TSP 3+
UNDTSP3-	57	A	Undedicated TSP 3-
UNDTSPS3	48	A	Shield For Undedicated TSP 3
UND4	58	A	Undedicated 4
UND5	59	A	Undedicated 5
UND6	60	A	Undedicated 6
UND7	64	A	Undedicated 7
UND8	65	A	Undedicated 8
UNDS	53	A	Shield For Undedicated 4-8
MDAOC	52	A	MDA Door Open/Close SIG To MDA
SW-6 NO	26	E	MDA Door Open Switch S6, Normally Open (Note 9)
SW-6 C	27	E	MDA Door Open Switch S6, Center Contact
SW-6 NC	28	E	MDA Door Open Switch S6, Normally Closed
SW-5 NO	36	E	MDA Door Open Switch S5, Normally Open
SW-5 C	37	E	MDA Door Open Switch S5, Center Contact
SW-5 NC	38	E	MDA Door Open Switch S5, Normally Closed

Safe/Arm Connector P3: (Note 10)

PYRO 1 PWR	A	B	---
PYRO 1 RET	B	B	---
PYRO 1 PWR (DEV)	G	B	---
PYRO 1 RET (DEV)	R	B	---
PYRO 2 PWR	N	B	---
PYRO 2 RET	C	B	---
PYRO 2 PWR (DEV)	J	B	---
PYRO 2 RET (DEV)	H	B	---
PYRO 3 PWR	P	B	---
PYRO 3 RET	D	B	---
PYRO 3 PWR (DEV)	L	B	---
PYRO 3 RET (DEV)	K	B	---
PYRO 4 PWR	F	B	---
PYRO 4 RET	E	B	---
PYRO 4 PWR (DEV)	M	B	---
PYRO 4 RTN (DEV)	S	B	---

Note 1: Power Return Pins B, D, And F May Be Connected Together Within Payload

Note 2: Wire Type Designation:

A	22 GA
B	16 GA
C	12 GA
D	26 GA
E	24 GA
F	20 GA

TABLE 2.5 CONTINUED

Note 3:	Customer will make no connections to unused pins
Note 4:	The designations "P1" and "P2" in this table indicate the pin-out for a cable-mounted connector. A canister experiment would need this termination to interface to the canister baseplate connector (designated as "J1" and "J2"). The pinouts are identical for either "J" or "P" designated connectors. Connector pair J3/P3 is a safe and arm connector whose use is not a standard service. The pin-out is not included.
Note 5:	28v b power circuit shared with MDA motors - may contain excess EMI during door motor operation.
Note 6:	Thermistor 1 is located on canister bottom plate
Note 7:	Pin 16 (MDA door position) may only be connected to high-resistance (100 k ohms) load within payload if MDA is flown
Note 8:	pin 20 BLCMD 4 to be connected to pin 52 (MDA open/close control) unless payload has other provision for generating 28v 10MA signal to open door (if MDA is flown).
Note 9:	When door is fully opened, normally open contact is shorted to center contact. When door is closed, normally closed contact is shorted to center contact.
Note 10:	Safe/arm connector is currently configured as a feed through, from outside Canister to experiment.
Note 11:	These services are no longer offered.

TABLE 2.6 CIRCUIT PROTECTION REQUIREMENTS

Min. Wire Gauge	Max. Fuse Size (A)	Max. Load (A)
26	3	1.5
24	5	2.5
22	6	3.0
20	7.5	3.75
18	10	5.0
16	12.5	6.25
14	15	7.5
12	25	12.5
10	30	15

Six electrical interfaces are provided via six standard sets of cables and connectors. Two additional sets are reserved for system use. These provide up to 500W of 28VDC power to each interface and 50W of "Survival Heater Power." In addition to providing this type of interface during on-orbit operations, the HH has provisions for a transparent bi-directional data path between the customer's payload and the Customer Ground Support Equipment (CGSE). This type of interface allows the customer to maintain autonomous control over his/her payload.

The characteristics of the power will be the same as Orbiter power except for higher source resistance due to the added carrier wiring. It is important to note that, while power is switched to each experiment through the HH avionics, no EMI filtering is provided. Customers will see the EMI environment specified in Appendix H and are expected to meet all EMI requirements by providing filtering with each experiment. Each power interface will consist of 28 VDC +/- 4 VDC power supplied via dual 12 gauge 10A circuits. Each of the dual circuits can be switched in through independent contacts of a Double-Pole Single Throw (DPST) relay (Figure 2.38). Each power interface will have independent current measurement capability.

2.3.3 DC Power Ripple and Transient Limits (For Payload Main Circuit Only)

See Appendix H of this document.

TABLE 2.7 CUSTOMER ELECTRICAL INTERFACES AND SERVICE SUMMARY

1. 28 VDC (+/- 4 VDC) Power (Dual 10A Circuits)
2. Asynchronous Interface (Bi-Directional, 1200 Baud)
3. Serial Command (Clock/Data/Envelope) can also function as Individual Bi-Level 0, +5v Commands (3 Each)
4. Bi-Level or Pulse 0, +28v Command (4 Each)
5. IRIG-B Met and Met One-Minute Pulse
6. Medium-Rate Ku-Band Data (16 Kb - 1.4 Mb/S Total, Clock/Data Interface)

Items 2, 3, 4, and 6 can be interfaced to customer GSE

Items 2 and 6 are "Transparent" interfaces

TABLE 2.8 HITCHHIKER ELECTRICAL ACCOMMODATIONS

	Total HH and Customer Payloads Max	Single Customer Payload Port Max
Power (28 +/- 4DC)	1300W	500w
Energy (KWH)	60	10 (Note 2)
Low-Rate Downlink	6000 B/S	960 B/S (Note 1)
Medium-Rate Downlink	1.4 Mb/S	1.4 Mb/S (Note 3)
Serial Command Channels	6	1 (Note 4)
Bi-Level Commands	24	4

Note 1: Nominal Information Rate Of One Standard Asynchronous Channel. Any Combination Of Five 1.2k Baud Channels May Be Downlinked Simultaneously.

Note 2: Nominal 1/6 Allocation.

Note 3: By Mission Requirements.

Note 4: These Services Are No Longer Offered.

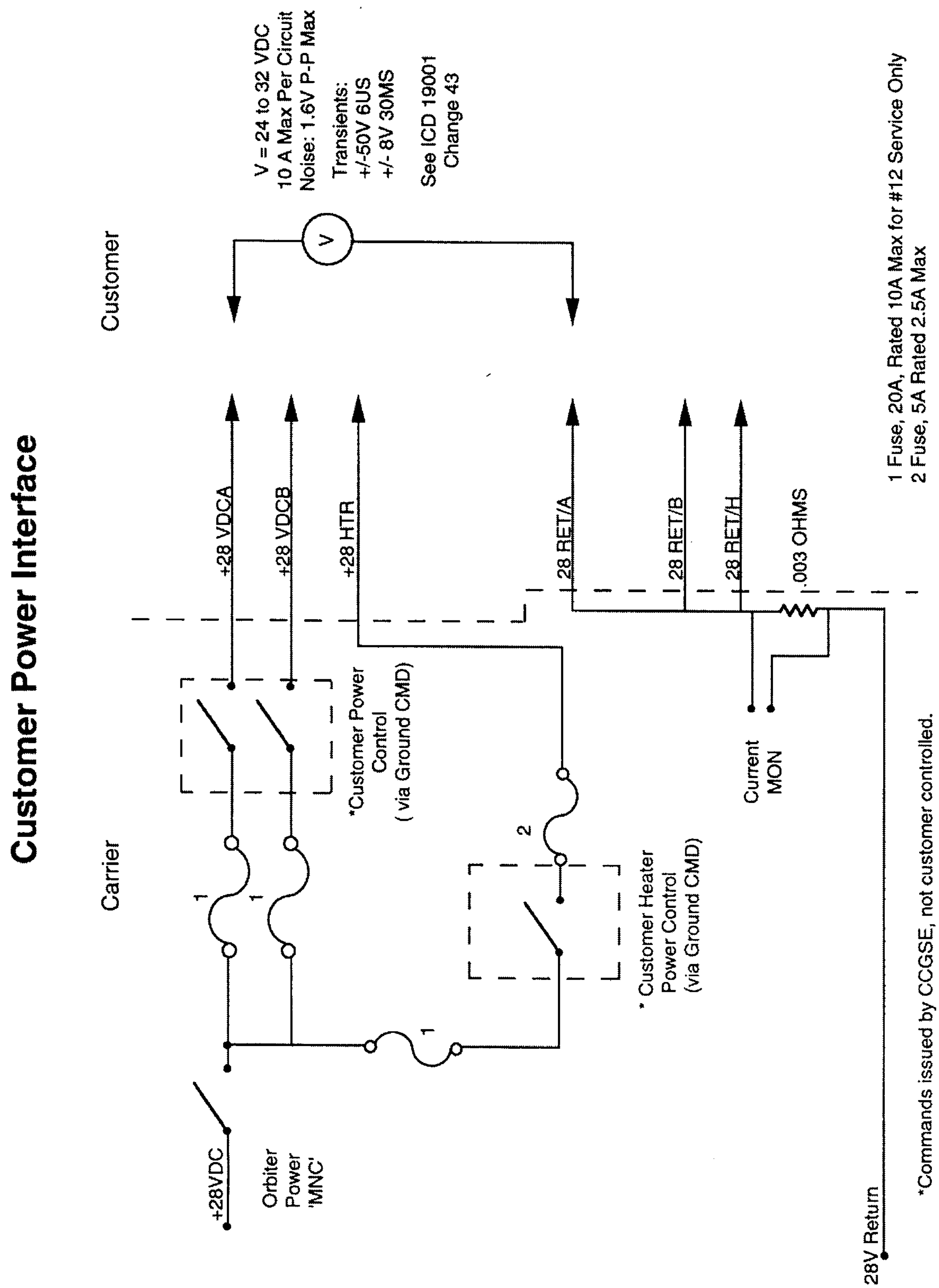


FIGURE 2.37 CUSTOMER POWER INTERFACE

In addition to the two 10-amp power lines, one 2.5-amp heater line is available at each power port. Heater service is controlled via a single relay for multiple customer ports. Therefore, power to this line shall be assumed ON for the duration of the flight. It is recommended that customers included internal (e.g., thermostatic) switching for this service.

Hitchhiker Avionics Unit - Power Distribution

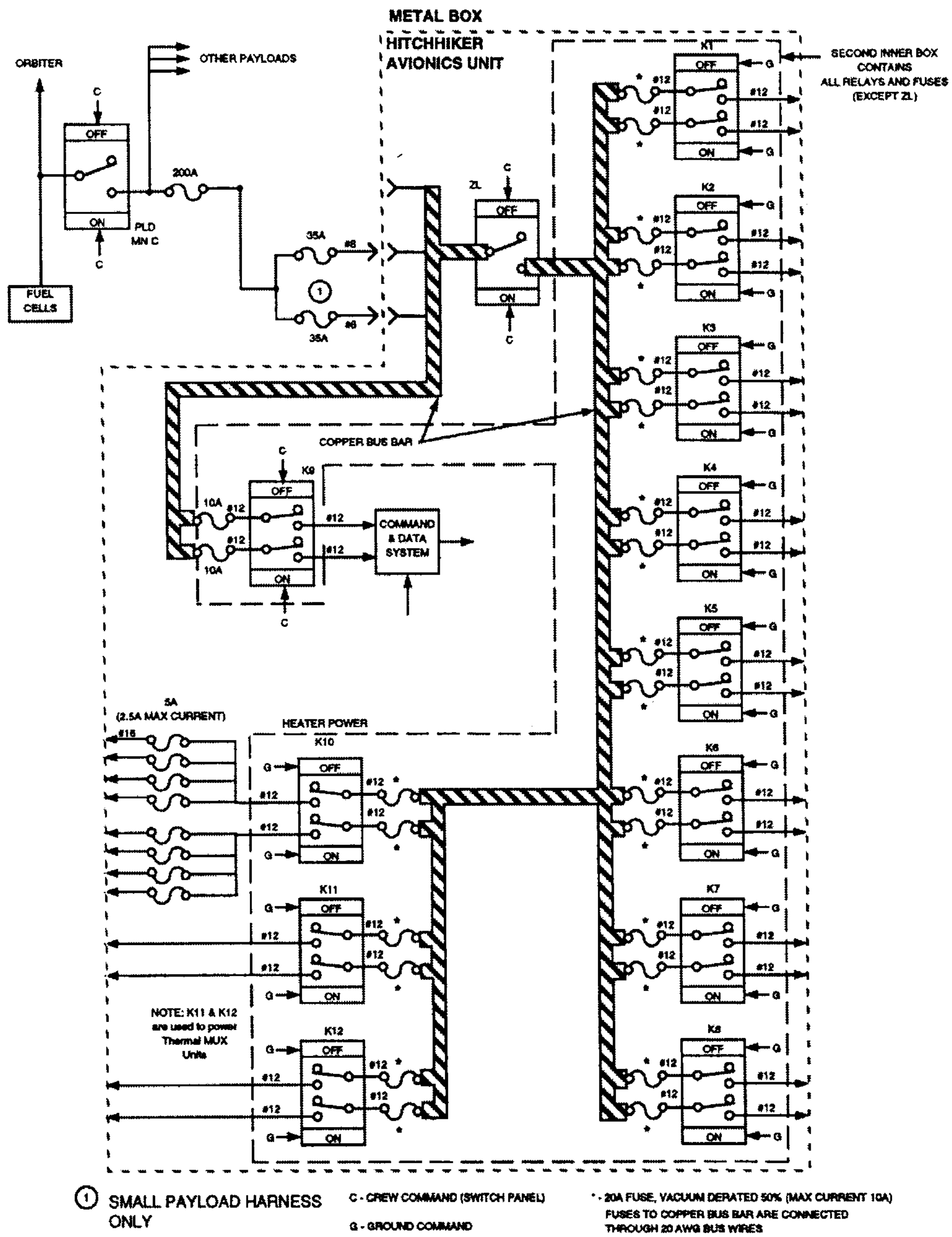


FIGURE 2.38 HITCHHIKER AVIONICS UNIT – POWER DISTRIBUTION

2.3.4 Thermal Power Characteristics

The thermistor characteristics that accomplish thermal control are specified in section 2.2.6.

2.3.5 Signal Characteristics

This data is available to the customer either in real-time or post-fight when specified as a requirement. Figure 2.40 provides a schematic drawing of the HH-S customer power interface. Customer signal ground must be connected to chassis (case). As shown in Figure 2.48, 28v return must be used for the bi-level return. The customer 28v return must be isolated from both signal ground and chassis (case) by a minimum resistance of 1M ohm. This requirement cannot be waived.

Tables 2.7 and 2.8 provide the detailed characteristics of the electrical system interfaces. A switch panel is used for carrier and experiment power activation and de-activation and may be used to provide a safety inhibit to a customer's hazardous function if required.

2.3.6 Standard Connectors for Customers

In choosing connectors for experiment internal wiring harnesses, it is highly recommended that the selection be limited to the MIL-C-38999 series I, II, or III or other space flight approved connectors. In the cases where GSFC is to supply the cables and harnesses as a service to the customer or where the connectors are otherwise specified within this document, the selection of connectors must be made from MIL-C-38999 to minimize cost and schedule impacts. GSFC will not be responsible for supplying connectors outside this specification. Sources of supply are as follows:

ITT Cannon
666 E. Dyer Road
P.O. Box 929
Santa Ana, CA 92702-0929

Amphenol Corporation
Bendix Connector Operations
40-60 Delaware Avenue
Sidney, NY 13838-1395

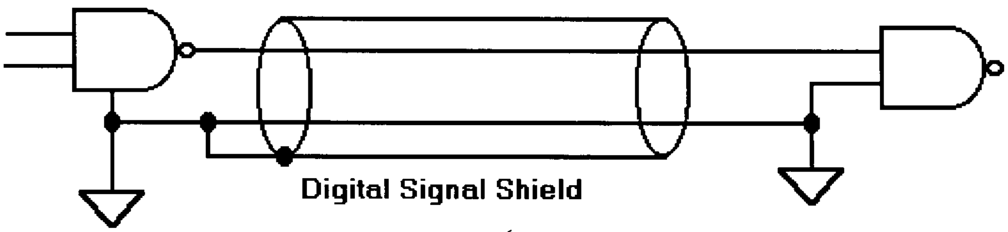
Matrix Sciences
365 Maple Avenue
Torrence, CA 90503

A detailed specification for this series of connectors may be obtained through the GSFC library or through the GSFC Code 300 library. Specific information regarding the manufacturer part numbering, cost, availability, etc. may be obtained from the above sources or through the GSFC electrical engineer assigned to the project.

2.3.7 Shield Grounding

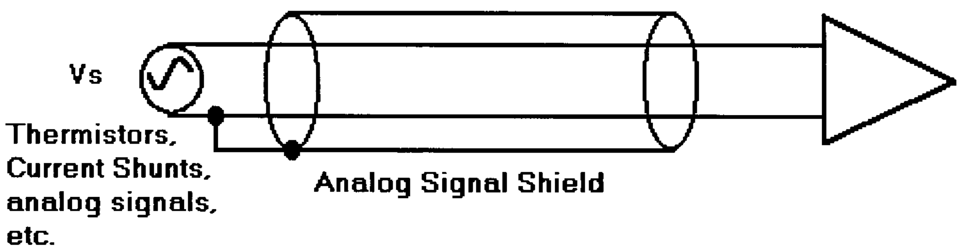
In order to maintain the EMC of the Hitchhiker and its customer, the following shielding practices will be used.

Refer to Figure 2.40. All logic level signals and analog signals excluding video and RF shall have their shields grounded to the signal ground at the sending end only. Signal returns will be routed in the same bundle as the associated signal lines in order to minimize electromagnetic emission and susceptibility.



a. Logic Level signal shield practice

FIGURE 2.39 DIGITAL SIGNAL SHIELD



b. Analog shielding practice

FIGURE 2.40 SHIELD GROUNDING OF LOGIC LEVEL AND ANALOG SIGNALS

All lines which carry significant current transitions while displaying "clean" constant voltages will be electromagnetically shielded (both ends grounded). Typically this will occur on power lines and the shields shall be grounded to chassis in these cases. Power distribution shall be through twisted pairs of wires in bundles separate from other signals. Refer to Figure 2.41.

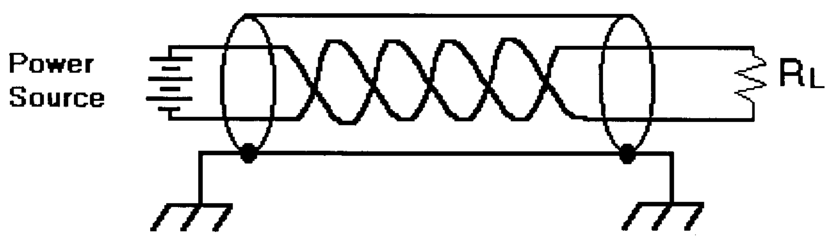


FIGURE 2.41 SHIELD GROUNDING OF POWER LINE

All lines which carry significant current and voltage transitions will be double shielded with an electrostatic shield (sending end grounded) and an electromagnetic shield (both ends grounded to chassis). Refer to Figure 2.42. This will occur on relay drive signals typically.

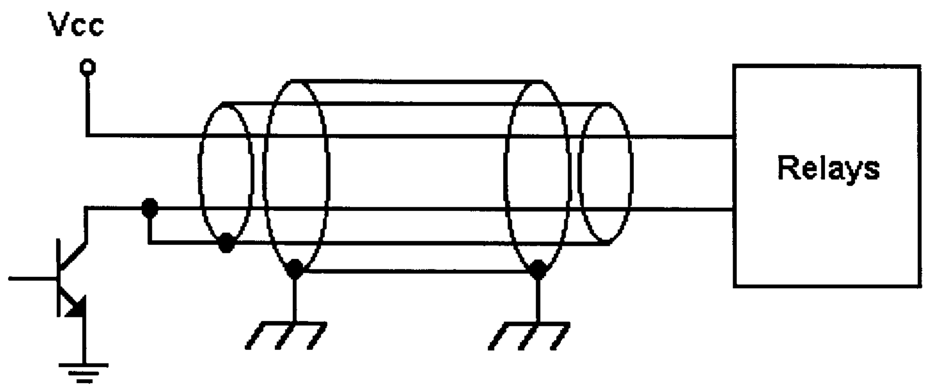


FIGURE 2.42 DOUBLE SHIELDING SIGNIFICANTLY VARYING CURRENT AND VOLTAGE LINES

2.4 Command And Communication Support System

2.4.1 Transparent Data System

Figures 2.43 through 2.47 illustrate the transparent data system available to the customer through HH. The figures present the command, low-rate and medium rate data flows. The data communications interface generally remains unchanged from the customer's point of view independent of whether the payload is at the customer's facility, at the integration facility, or during flight operations. Some ground data processing functions may have optional service charges for reimbursable customers. Contact the Project Office for details.

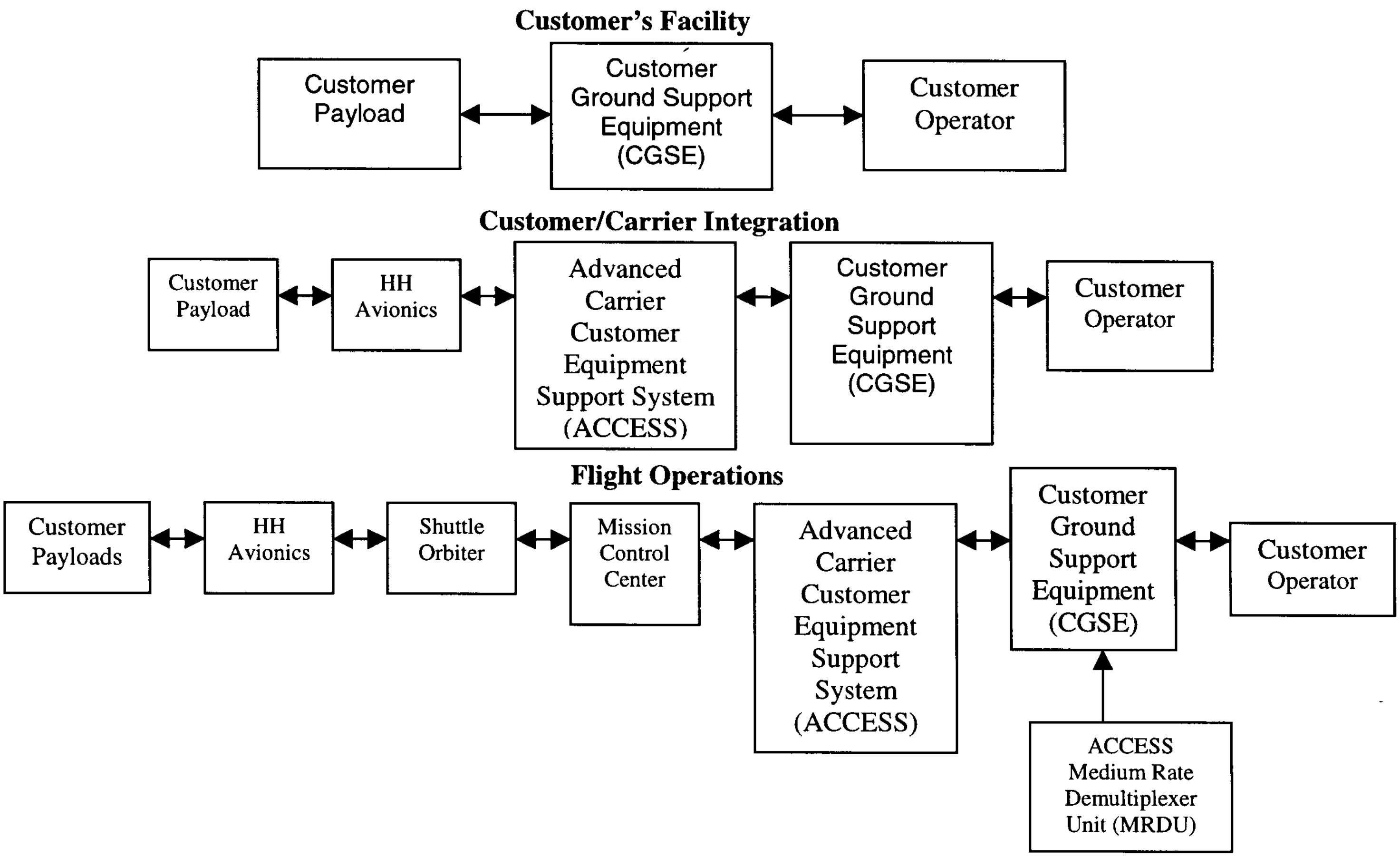


FIGURE 2.43 HITCHHIKER TRANSPARENT DATA SYSTEM

Hitchhiker Command Flow

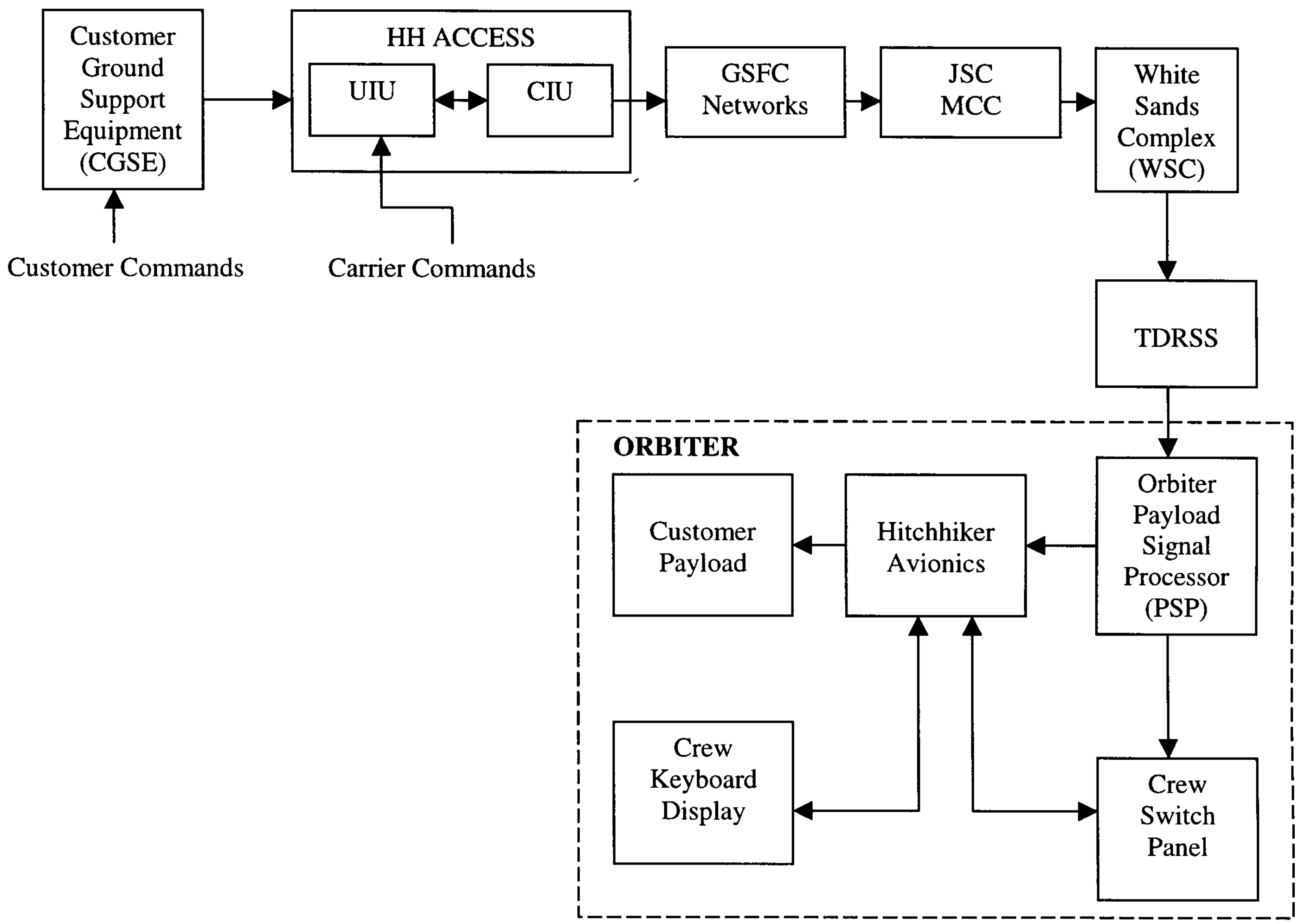


FIGURE 2.44 HITCHHIKER COMMAND FLOW

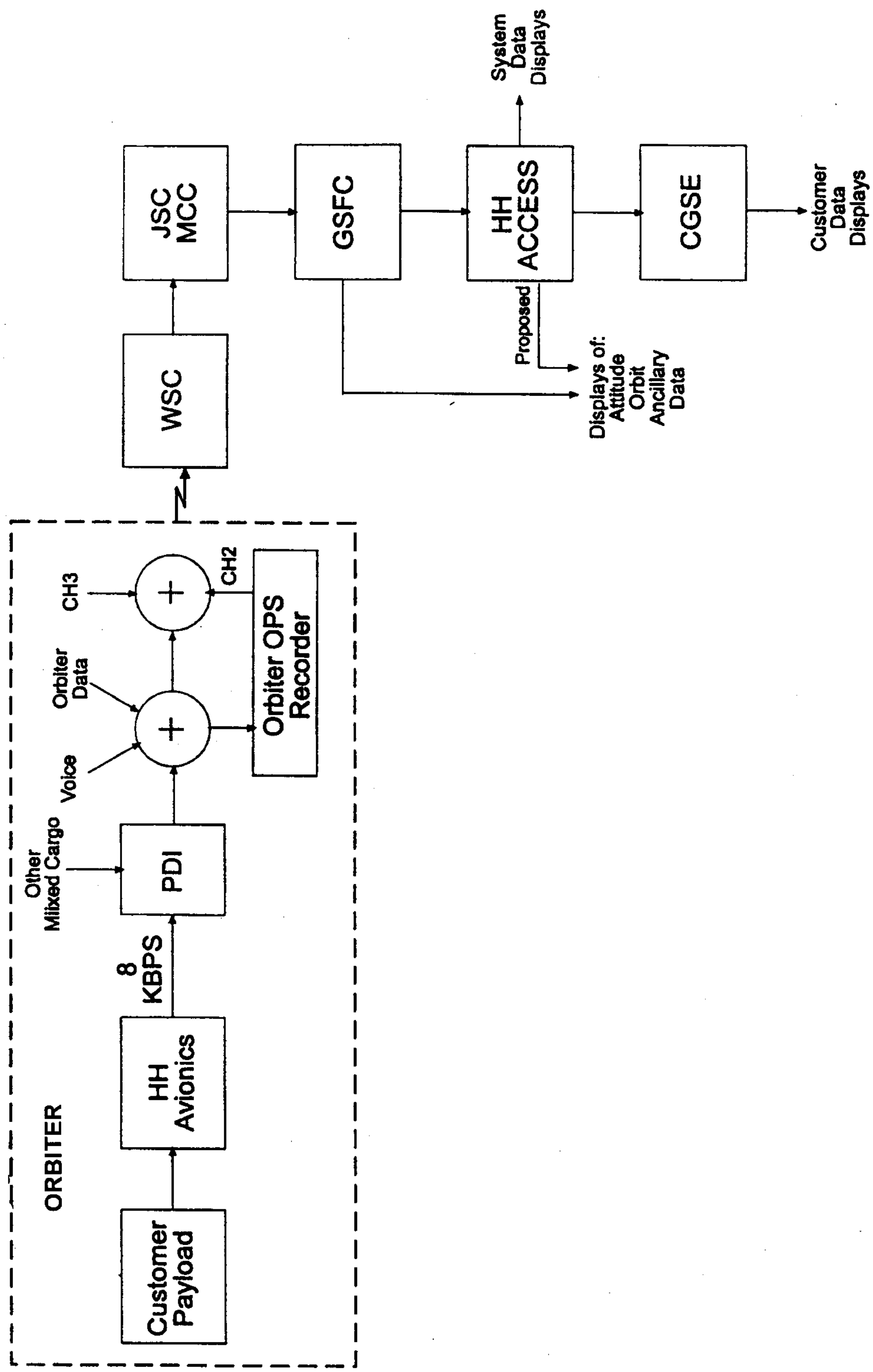


FIGURE 2.45 HITCHHIKER LOW RATE DATA FLOW

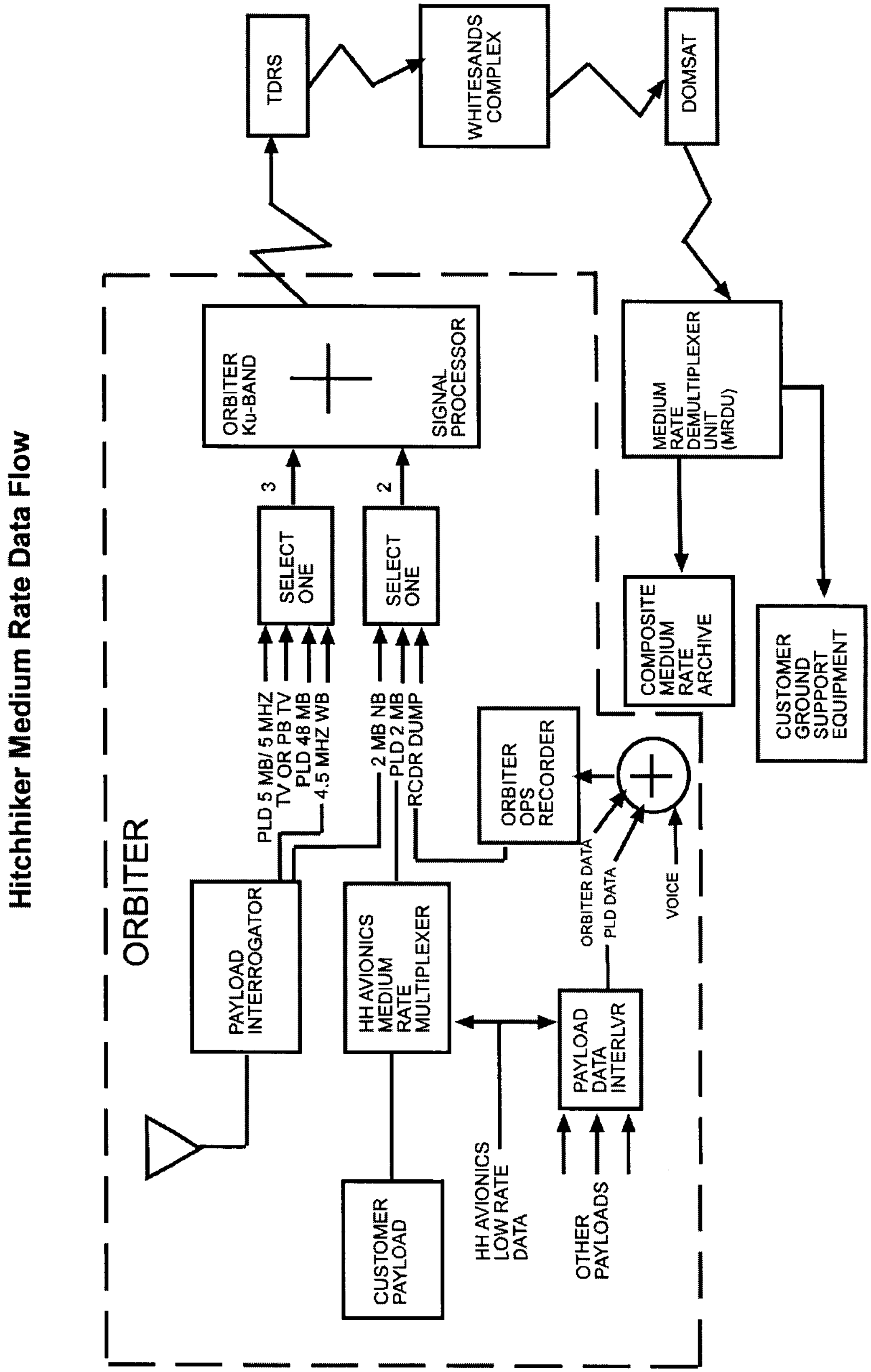


FIGURE 2.46 HITCHHIKER MEDIUM RATE DATA FLOW

Hitchhiker Signal Port to Customer Interface

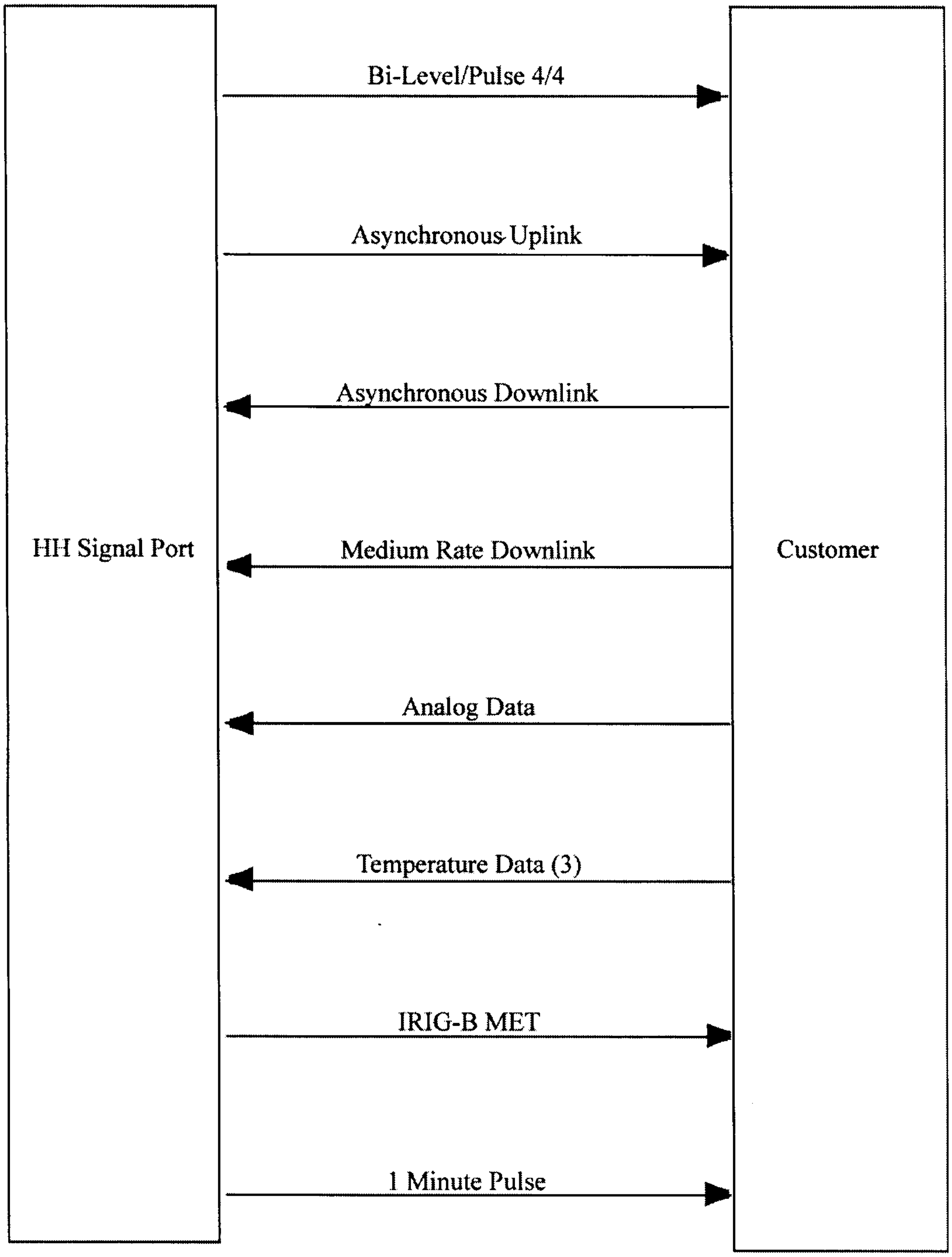
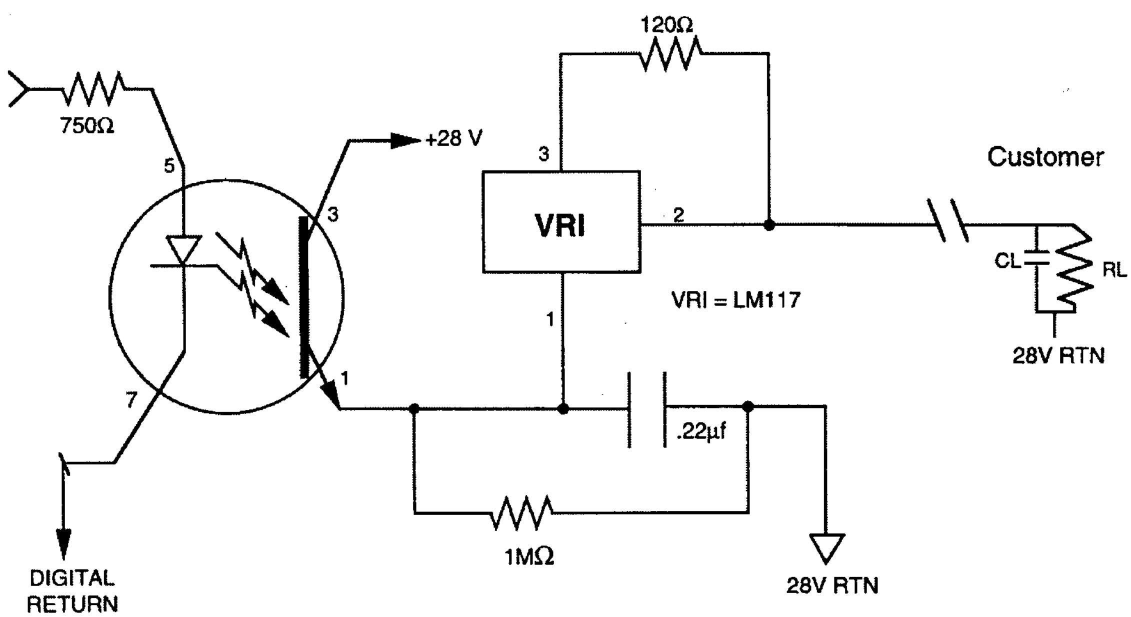


FIGURE 2.47 HITCHHIKER SIGNAL PORT TO CUSTOMER INTERFACE

2.4.2 Bi-Level Command System

Signals that traverse the bi-level command interface may be set to ØV (false) or +28V (+19.5 to +32V) (true), or may be pulsed from false to true and back to false. There are four bi-level signals per interface. Figure 2.48 illustrates the customer bi-level command interface while Figures 2.49 and 2.50 show the command formats. Only one of the four signals may be affected by any one command. Bi-level commands can be sent either via ACCESS or CGSE.

CUSTOMER BI-LEVEL COMMAND INTERFACE



RL = 3.2K OHMS Min. (Customer Power On or Off)
RL = 10K Ohms Max, (Source 10ma Max; Sink 0)
CL = 1500 PF Max,
VT = 26 +/- 7V
VF = 1.5 +/- 1.5V
VNOISE = 1.6 V P-P (Max.)
TR = TF= 10 Microsec(Min)
TR = TF= 100 Microsec (Max)
T1 = 50 +/- 30 MS (Pulse Mode)

FIGURE 2.48 CUSTOMER BI-LEVEL COMMAND INTERFACE

Customer Message Format for 28 Volt Bi-Level Commands

1	2	3	4	5	6	7	8
1	1	1	0	0	1	0	1
0	0	0	0	0	0	0	1
CID				0	0	1	1
S4	S3	S2	S1	R4	R3	R2	R1
CHECK							

S1-S4 Set Bi-Level 1-4 True = 28V
R1-R4 Reset Bi-Level 1-4 to False = 0V
RN and SN Simultaneously True = Error, No Action
Type = 3, Byte Count = 1. Any Bi-Level Command Lines Not Selected by Ones in SN, RN Will Not Be Affected

Customer Line Numbers

Only One Bi-Level Line May be Set/Reset by a Single Command.

Note: 28 volt bi-level and 28 volt pulse commands use the same 4 wires per customer interface (17,18,19,20).

FIGURE 2.49 CUSTOMER MESSAGE FORMAT FOR 28 VOLT BI-LEVEL COMMANDS

Customer Message Format For 28 Volt Pulse Commands

1	2	3	4	5	6	7	8	
1	1	1	0	0	1	0	1	P1 -P4+ 1 PULSE BI-LEVEL LINE 1-4 SETS SELECTED BI-LEVEL LINES(S) ON CUSTOMER PORT CID TO TRUE (+28V) FOR 20- 80 MILLISECONDS THEN RETURNS LINE TO FALSE (OV). STATES OF ANY BI-LEVEL COMMAND LINES NOT SELECTED BY ONES ARE NOT AFFECTED. CUSTOMERS DESIGN MUST BE CAPABLE OF WITHSTANDING CONTINUOUS +28V ON ANY BI-LEVEL LINE WITH NO DAMAGE IN EVENT OF SOFTWARE FAILURE. TYPE =5, BYTE COUNT =1
0	0	0	0	0	0	0	1	
CID				0	1	0	1	CUSTOMER LINE NUMBERS
0	0	0	0	P4	P3	P2	P1	ONLY ONE LINE MAY BE PULSED BY A SINGLE COMMAND.
CHECK								

NOTE: 28 VOLT PULSE AND 28 VOLT BI-LEVEL COMMAND USE THE SAME 4 WIRES PER CUSTOMER INTERFACE (17,18, 19, 20)

FIGURE 2.50 CUSTOMER MESSAGE FORMAT FOR 28 VOLT PULSE COMMANDS

2.4.3 Asynchronous Uplink

The asynchronous uplink is used to transmit customer asynchronous command messages and Mission Elapsed Time (MET) messages to the payload. All commands issued by the CGSE have the general format shown in Figure 2.51

The customer message format for asynchronous commands is shown in Figure 2.52. The format of the asynchronous MET message is shown in Figure 2.53. The format of the synchronize to MET command is shown on Figure 2.54 One receive data (RD) signal is available through each HH port.

The interface operates at 1200 baud asynchronous data rate. The signal format is shown in Figure 2.55 where each signal contains one start bit, eight data bits (no parity), and one stop bit. The uplink messages may originate from the ACCESS or from CGSE. The transport delay between CGSE and the customer's payload is nominally 2 to 20 seconds. The transport delays are due to latencies introduced by the number of CGSEs issuing commands, the networks, JSC Mission Control Center (MCC) and uplink delays. The delay does not account for retrying a command because of command uplink failure.

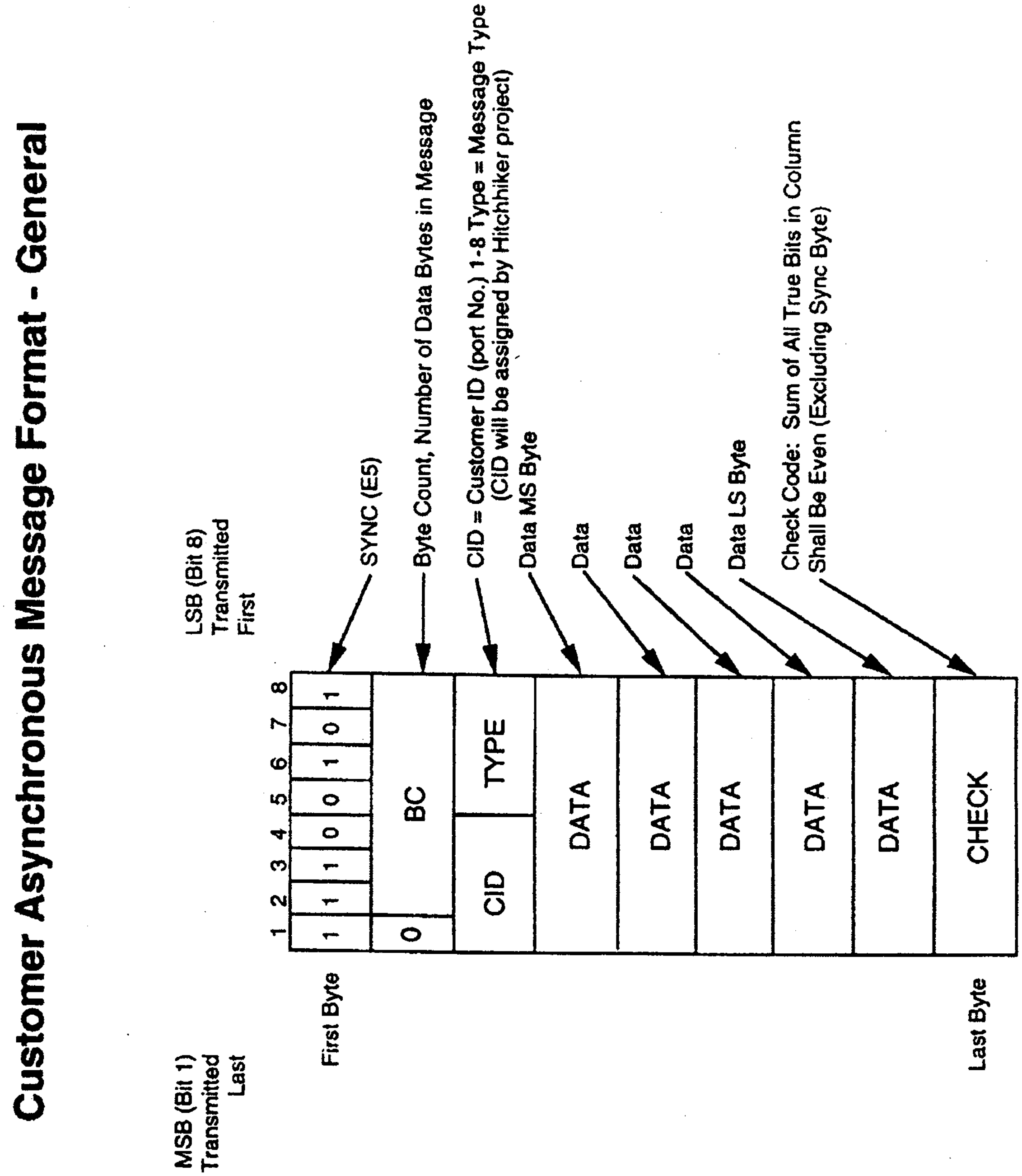
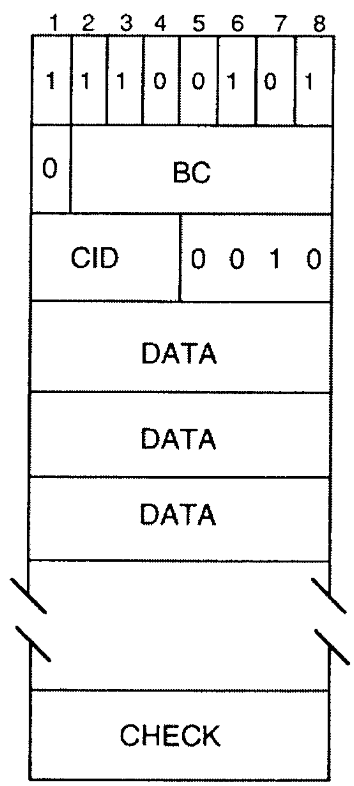


FIGURE 2.51 CUSTOMER ASYNCHRONOUS MESSAGE FORMAT – GENERAL

Customer Message Format for Asynchronous Commands



Entire Message Including Sync and
Check Bytes to be Transmitted to
Customer Port CID
RD Asynchronous on Pins 21 & 22.
Type = 2

Format of CGSE Message Identical

FIGURE 2.52 CUSTOMER FORMAT FOR ASYNCHRONOUS COMMANDS

Customer Message Format For MET

1	2	3	4	5	6	7	8
1	1	1	0	0	1	0	1
0	0	0	0	0	1	0	0
CID				0	1	0	0
D1	D2	D3	D4	D5	D6	D7	D8
D9	D10	H1	H2	H3	H4	H5	H6
0	M1	M2	M3	M4	M5	M6	M7
0	S1	S2	S3	S4	S5	S6	S7
CHECK							

D1-200 DAYS	H1-20 HOURS	M1-40 MIN	S1-40 SEC
D2 -100	H2-10	M2-20	S2-20
D3-80	H3-8	M3-10	S3-10
D4-40	H4-4	M4-8	S4-8
D5-20	H5-2	M5-4	S5-4
D6-10	H6-1	M6-2	S6-2
D7-8		M7-1	S7-1
D8-4			
D9-2			
D10-1			

4 BYTES

Command to be transmitted to customer payload asynchronous port at a time other than MET second 1 or 59. The 4 bytes of time data will be filled in by the SPOC avionics using Orbiter supplied time. When sent by the customer, the 4 bytes are "don't care" and may contain anything. CGSE command with dummy data initiates transmission of MET command, type=4.

FIGURE 2.53 CUSTOMER MESSAGE FOR MET

Customer Message Format for Synchronized MET

1	2	3	4	5	6	7	8	
1	1	1	0	0	1	0	1	
0	0	0	0	0	1	0	0	Byte Count
CID				0	1	1	0	Subcommand Type 6
D 1	D 2	D 3	D 4	D 5	D 6	D 7	D 8	
D 9	D 10	H 1	H 2	H 3	H 4	H 5	H 6	
0	M 1	M 2	M 3	M 4	M 5	M 6	M 7	
0	S 0	S 0	S 0	S 0	S 0	S 0	S 0	
CHECK								Checksum

Notes:

1. Unless MET is within ±5 seconds of the new minute, the next minute represented by the minute pulse is sent via the RS-422 Asynchronous Interface.
   If MET is within 5 seconds of the new minute, then the time sent to the customer is the <u>NEXT</u> minute, not the upcoming minute.

2. This command is not implemented in some HH avionics. Check with HH project for availability.

FIGURE 2.54 CUSTOMER MESSAGE FORMAT FOR SYNCHRONIZED MET

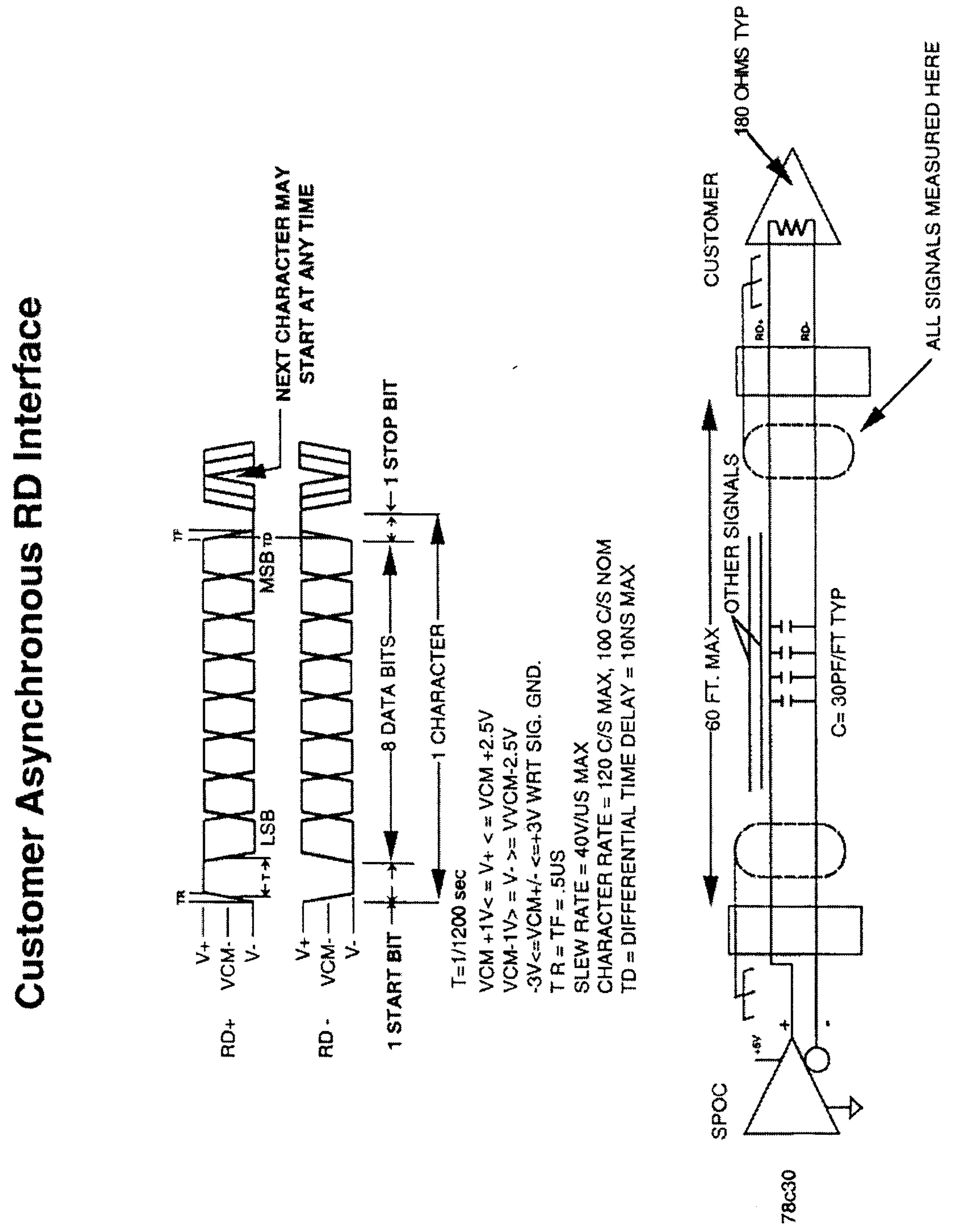


FIGURE 2.55 CUSTOMER ASYNCHRONOUS RD INTERFACE

2.4.4 Asynchronous Downlink

One Asynchronous Send Data (SD) signal per interface that operates at 1200-baud asynchronous and has a similar message pattern (one bit start, 8 data bits, and one stop bit) as the uplink interface is available through the HH interface. (See Figure 2.56).

The downlink can support continuous 1200-baud transmission which will be routed to the customer's GSE via the ACCESS to CGSE interfaces. Downlink messages do not have a format requirement. Nominally, the transport delay between customer payload and customer GSE is 5 to 15 seconds. The standard HH avionics arrangement can simultaneously downlink any 5 of the 8 available asynchronous downlink channels. These channels are selectable via ground system commands from the ACCESS.

Customer Asynchronous SD Interface

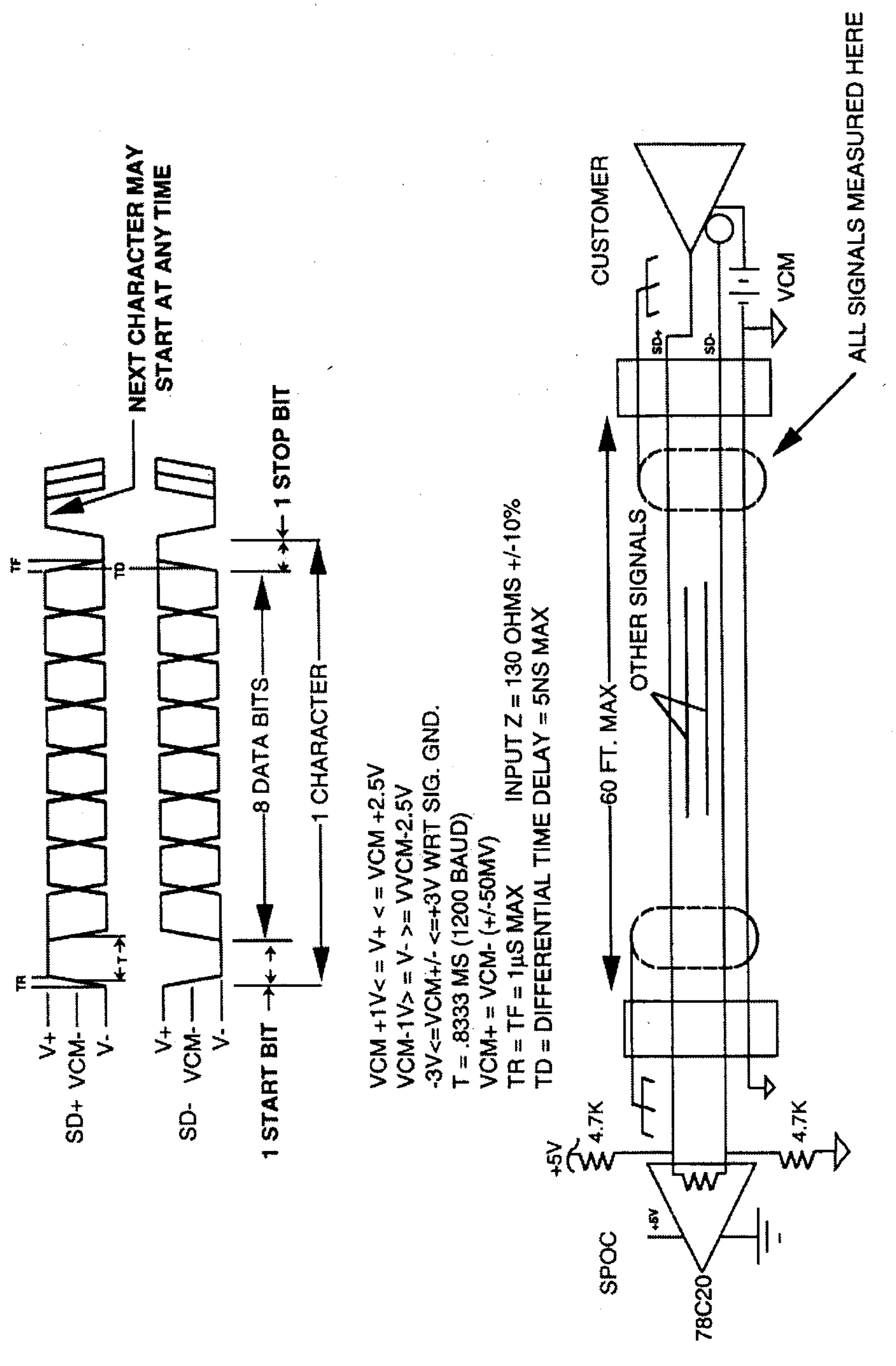


FIGURE 2.56 CUSTOMER ASYNCHRONOUS SD INTERFACE

2.4.5 Medium-Rate Ku-Band Downlink

The carrier contains a Medium-rate Multiplexer (MRM) capable of multiplexing up to six simultaneous customer-provided serial-bit non-return to zero (NRZ) data signals into a single serial 2Mb/s bit-stream for transmission via channel 2 of the Orbiter Ku-band Tracking and Data Relay Satellite System (TDRSS) signal processing system. The combined simultaneous input rate to the MRM from all HH experiments cannot exceed 1.4 Mb/s. This effectively limits customer downlink rates if the MRM is accepting data from more than one source. As previously shown in Figure 2.45, channel 2 is not available for exclusive use of HH data but is shared with dumping of the Orbiter's tape recorder and the payload interrogator. In addition, use of the medium-rate system requires the TDRSS as well as deployment and pointing of a steerable antenna on the Orbiter which cannot be used in certain attitudes or orbit positions. In general, Ku-band medium-rate service should be available approximately 50 percent of the time during a typical flight.

Medium-rate data accommodations will be allocated by the SSPP on a case-by-case basis. This allocation will depend on several factors, including experiment data rate, mission timeline, and the requirements of other co-manifested experiments. The maximum data rate per user channel is 880 kbps. If conflicts exist between several medium-rate users, then medium-rate data output must be controllable via CGSE ground command.

Each customer-supplied input data stream must be continuous and stable within 1 percent of its assigned data rate during the customer's data-take periods. If the customer's data is discontinuous or event-oriented, the customer may elect to have the clock stop between periods of valid data, or may elect to transmit continuous clock but discontinue transmitting valid data.

It is recommended that each valid period be preceded by at least 4 data frames of leader telemetry prior to the first frame of required data. This is needed in order to ensure that the ACCESS ground data system has sufficient time to sync on the composite downlink signal during mission. Each data period must be followed by at least 66 bytes of clock to flush the customer data buffer in the MRM.

Customer data during valid data periods must consist of a continuous series of data frames each containing a fixed integral multiple of 8 bits but no more than 8,192 bits. Each data frame must contain a fixed synchronization pattern of at least 24 bits to be specified by the customer. The pattern FAF320 (hexadecimal, most significant bit and byte first) is recommended but may be customer selected. The remaining format of the data frames can be determined by the customer as desired; however, the following considerations should be taken into account. Each data frame should contain a frame number that does not repeat for at least 256 frames, as well as time information adequate for the customer's needs; it should also contain provision for error detection if necessary to meet the customer' goals.

During testing and flight operations, the Medium Rate Demultiplexer Unit (MRDU), referenced in Figure 2.46, will decommutate the multiplexed signal and regenerate the customer's clock and data for use by the CGSE. This data interface is shown in Table 2.12. The clock will generally be at a slightly higher bit rate than the onboard customer supplied clock. The ground clock and data will stop momentarily periodically to equalize the average data rate.

The data bit error rate is expected to be generally no worse than 10^{-5}; however, there will be periods of dropout and deteriorated data especially near the ends of TDRSS coverage periods. The data delay will be several hundred bytes plus approximately 2 seconds. The CGSE must be designed to obtain and maintain synchronization and otherwise operate in a satisfactory manner under these conditions.

The electrical interfaces and timing for the medium-rate system are shown in Figures 2.57, 2.58 and 2.59. Data return on the ground can be either by NRZ-L serial data and clock interface identical to Figures 2.58 and 2.59 or post mission by Compact Disc (CD). The CD format is shown in Appendix C and will be frame synchronized data sets if the customer uses a fixed-frame length. GSFC engineers can assist customers in the design of prospective medium rate (MR) telemetry formats. Again, the customer's medium-rate ground data interface is shown in Table 2.12.

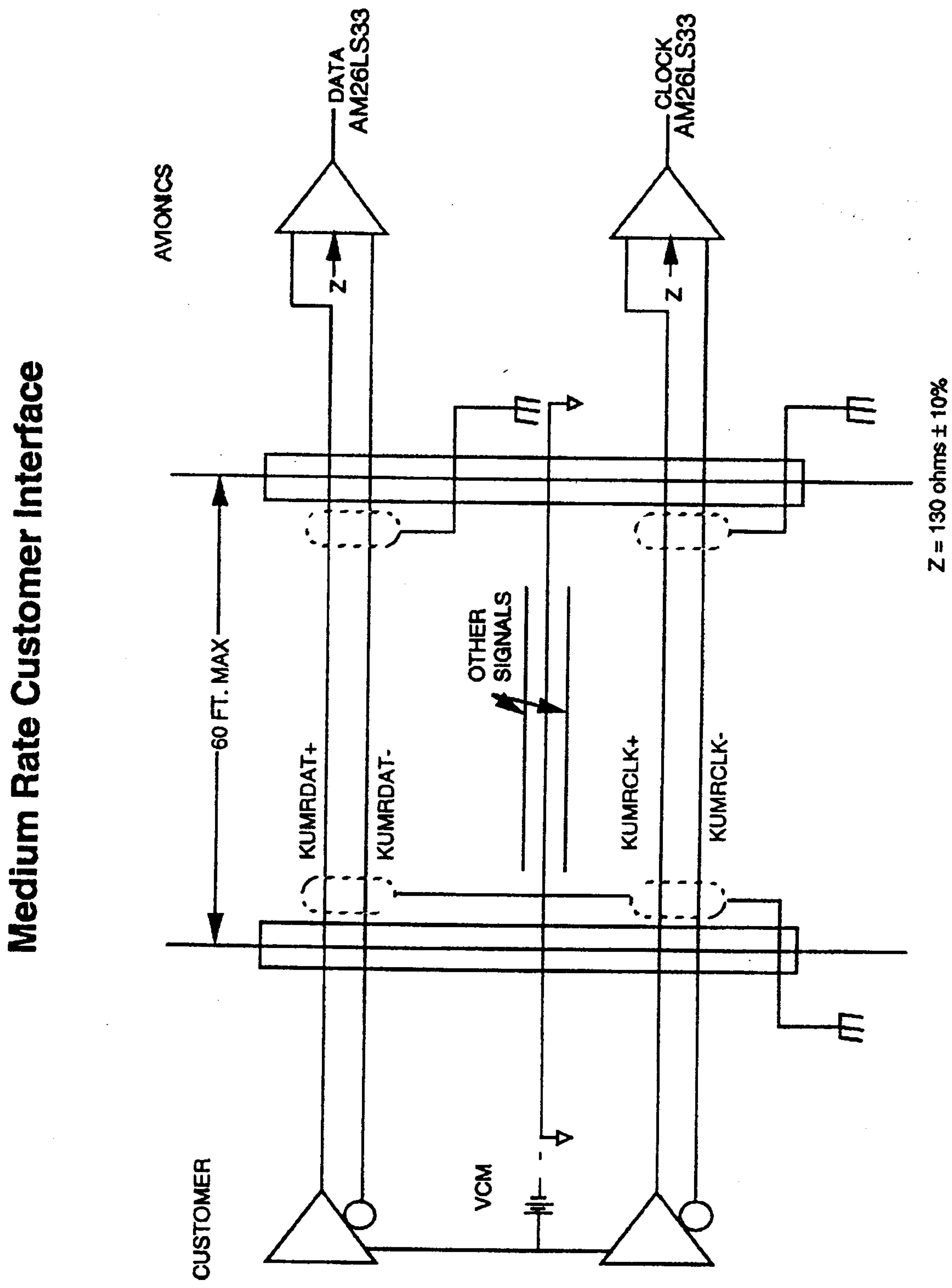
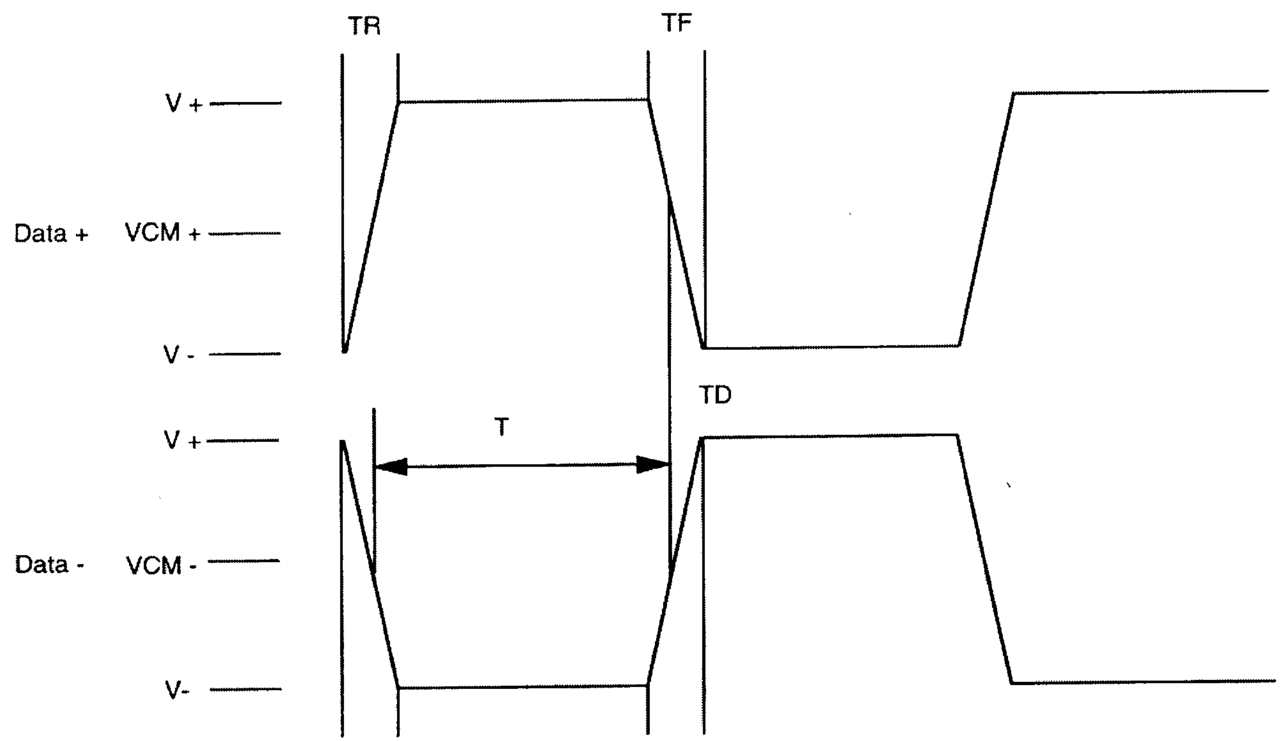


FIGURE 2.57 MEDIUM RATE CUSTOMER INTERFACE

Medium Rate Customer Data



Required: VCM+ = VCM- +/-50MV, Then VCM+ = VCM- = VCM
Required: VCM + 1 volt $\leq$ V + $\leq$ VCM + 2.5V
Required: VCM - 1 volt $\geq$ V - $\geq$ VCM - 2.5V
Required: -3 volts $\leq$ VCM $\leq$ + 3 volts with respect to signal ground

For Data + and Data- Lines

TR $\leq$ TF $\leq$ 1US

T = Baud Period = 1/Baud Rate   Baud Rate = TBD
T = Differential Time Delay = 10 MS Max
Baud Rate Stability $\leq$ 0.1%

FIGURE 2.58 MEDIUM RATE CUSTOMER DATA

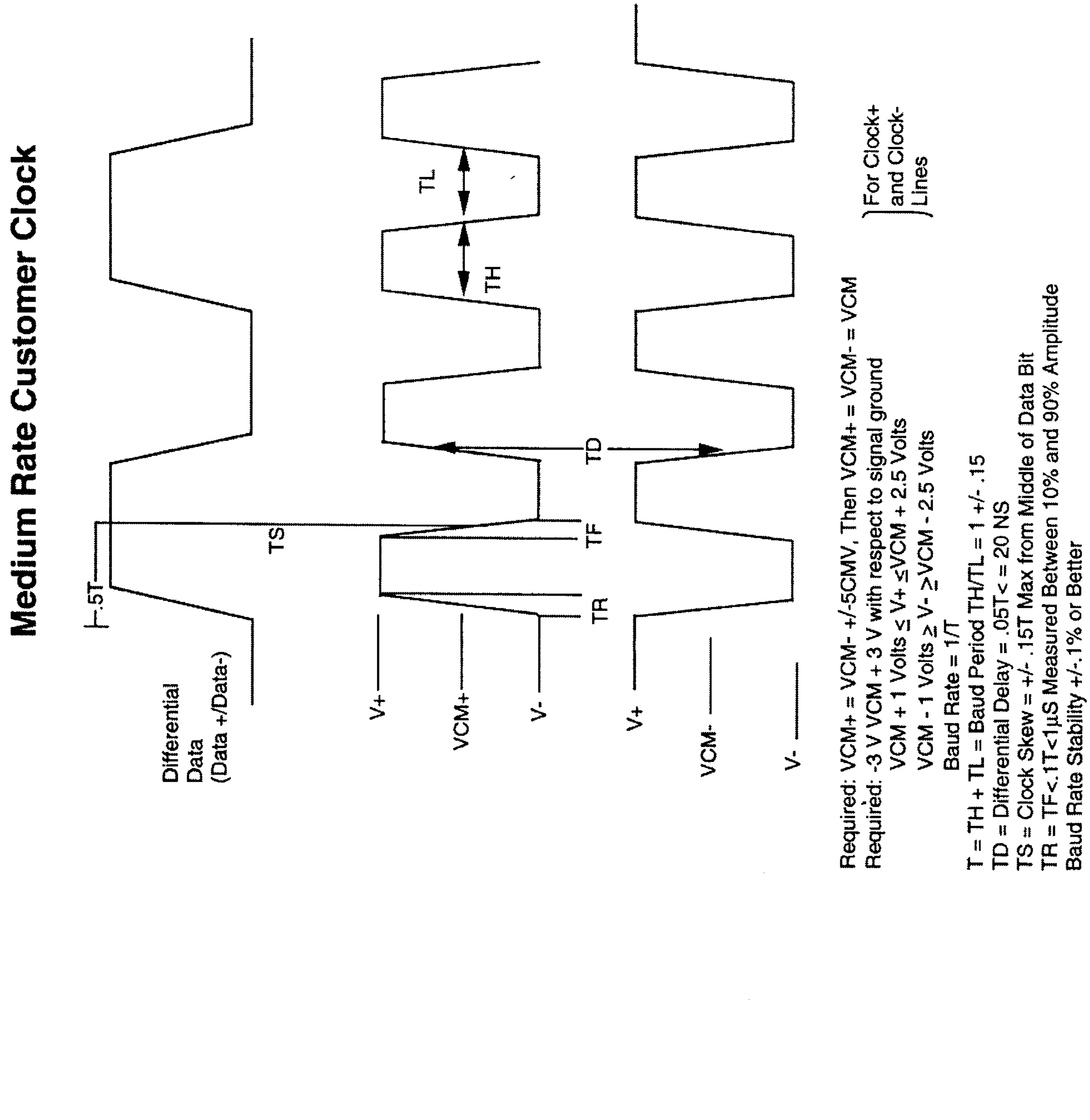


FIGURE 2.59 MEDIUM RATE CUSTOMER CLOCK

2.4.6 Analog Data

One analog data line is provided in each standard interface. This line is sampled at a rate of approximately 15 Hz. Voltages in the range of -0.06 to 5.04 volts are converted to 8-bit values (00 and FF, respectively). Voltages slightly below -0.06 or above 5.04 volts will be transmitted as 00 or FF (i.e., no foldover occurs). An index pulse on a separate wire occurs once per sample and can be used to advance a customer-supplied analog multiplexer to allow multiple parameters to be sampled over the single analog line. Several (typically three) of the multiplexer's inputs should be connected to known fixed voltages (e.g., +5.10, zero, +2.50) to allow the customer's ground equipment to determine synchronization with the returned sample sequence. Analog interfaces are shown in Figure 2.60.

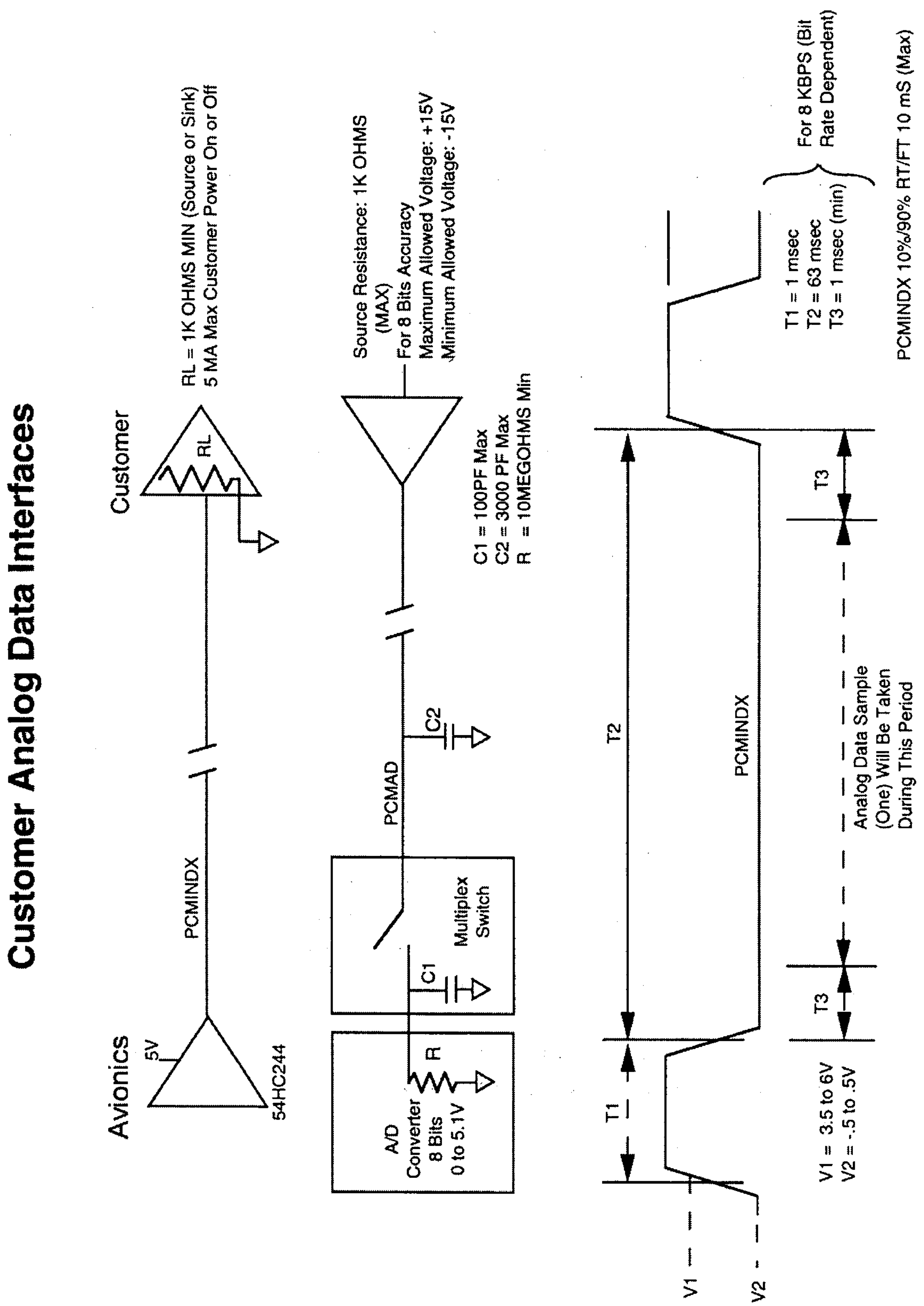


FIGURE 2.60 CUSTOMER ANALOG DATA INTERFACES

2.4.7 Temperature Data

As provided in each interface, three additional analog data lines (Figure 2.33) are sampled at approximately .5 Hz (-0.06 - +5.04v, 8 bits) and are provided with a regulated power source and resistor network. These are intended for connection to YSI 44006 (see Section 2.2.2) thermistors to be supplied by GSFC and installed inside the customer's flight equipment by the customer. These networks and thermistors allow temperatures in the range of -20 to +60 degrees C to be measured without requiring the customer equipment to be operating. If all the thermistor lines are not required for temperatures, they may be used by the customer to measure other parameters such as: canister temperature, bottom plate temperature, canister pressure, and door position (if door is present).

2.4.8 Inter-Range Instrumentation Group, Type B (IRIG-B) MET Signal

Orbiter MET in IRIG-B format will be distributed to each interface. This signal is maintained to within 10 milliseconds (ms) and consists of a 100 Pulse Per Second (PPS) Pulse-Width-Type PCM signal giving days, hours, minutes, and seconds, once each second. In addition, there will be a MET minute signal; Transistor-Transistor Logic (TTL) levels, nominal square wave 1 ppm; edges traceable to MET within 10 ms. The customer timing interface is shown in Figure 2.60. Greenwich Mean Time (GMT) may be used in place of MET on some HH missions.

Real-time data transmitted to customer's GSE can usually be tagged by the customer's software to within 10 seconds. Therefore no time signals may be necessary at the customer's payload if time knowledge to within 10 seconds is adequate. If it is necessary to have time knowledge within the customer's payload, the MET minute signal can be used to reset a customer one-minute clock to 10 milliseconds accuracy. If the customer is using the asynchronous command channel, day-hour-minute-second time may be sent to the customer's payload periodically to update an on-board clock to within 3 seconds. This may be used in conjunction with the above minute pulse to obtain maximum accuracy. The IRIG time signal may also be decoded to obtain day-hour-minute-second time to within 10 milliseconds but is recommended only for existing designs because of the larger number of electronic parts required for decoding.

The signal characteristics of this interface are described in paragraph 8.2.10 of JSC 07700 Vol. XIV Attachment 1 OICD 2-19001) SHUTTLE ORBITER/CARGO STANDARD INTERFACES. This paragraph follows.

> [8.2.10.1.1] GMT (in HH Application, MET). The absolute time data, at any given time during a seven-day mission, shall not deviate by more than +/- 10 milliseconds from the groundstation MET Reference Time Standard and shall be synchronized with the ground MET at certain times during a mission, subject to mission procedural constraints to prevent ring unacceptable time base perturbations. The accuracy of these time updates shall be +/- 5 milliseconds. The Master Timing Unit (MTU) frequency offset and drift rates shall constrain the time error growth rate to a maximum of +/- 10 milliseconds per 24 hours.

The MET output format is modified IRIG-B as shown in Figure 2.62. The electrical interface characteristics are shown in Figure 2.61.

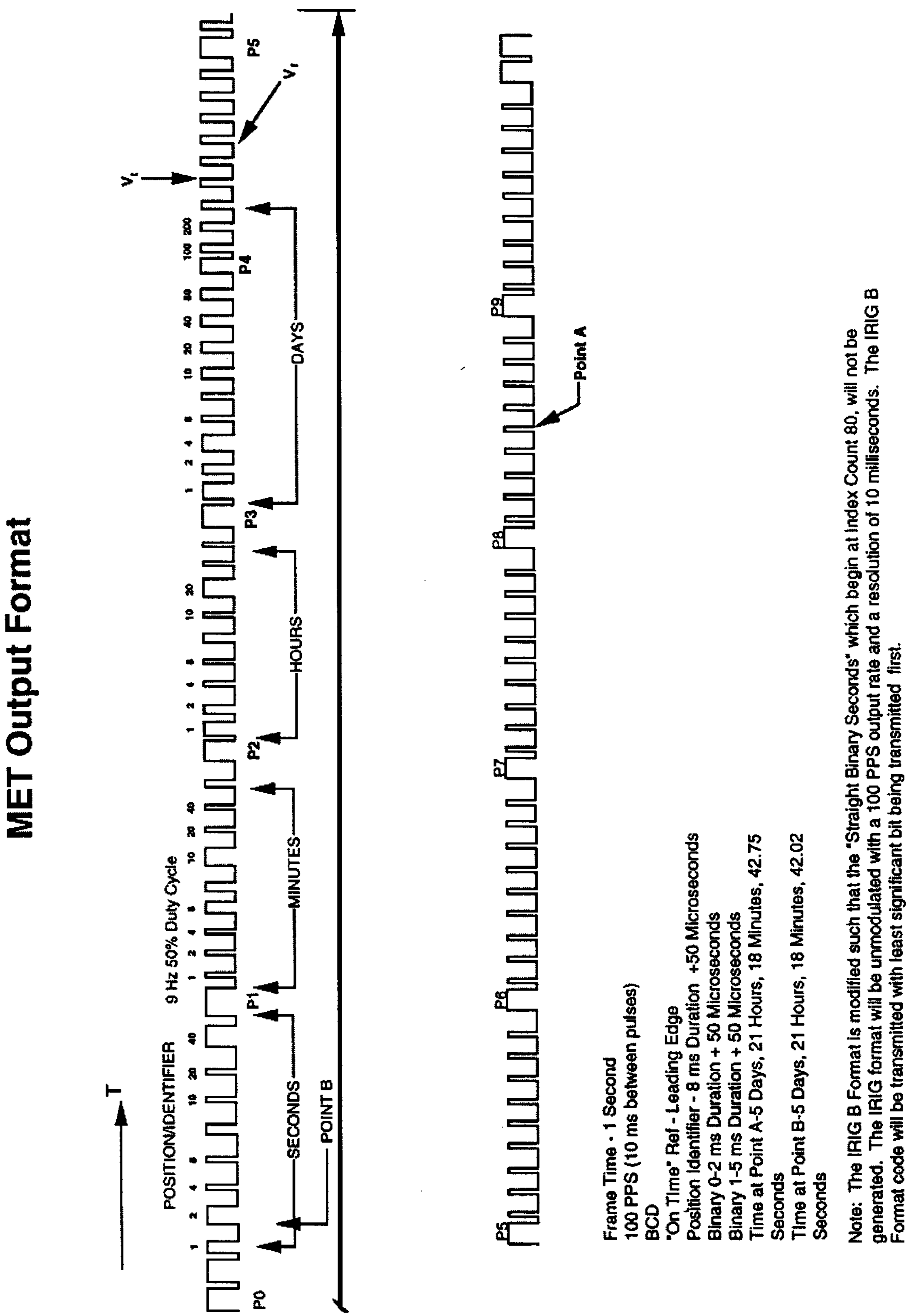


FIGURE 2.62 MET OUTPUT FORMAT

2.4.9 ACCESS/CGSE Interface

Overall communication between the customer's payload and their ground support equipment are shown in Figure 2.63. The ACCESS provides the customer with (1) the command interface between the CGSE and the customer payload, (2) low-rate customer payload data as telemetered by the HH avionics, and (3) Orbiter ancillary data. The ACCESS provides two asynchronous data lines for these purposes.

The Advanced Carrier Customer Equipment Support System (ACCESS) is a Pentium PC-based, networked system that allows customers to receive telemetry from and send commands to their experiment during Integration and Test (I&T) and mission operations. The ACCESS system consists of the User Interface Unit (UIU) and the Carrier Interface Unit (CIU) and the Medium Rate Demultiplexer Unit (MRDU). Figures 2.63 and 2.64 illustrate the Hitchhiker ACCESS system. ACCESS can also provide data displays for each customer and thermal plotting capabilities.

The UIU is the main console for the system operator. Its overall function is to ingest low rate telemetry packets via the network from the CIU and distribute user packets via the ARNET RS232/RS422 ports. It allows the operator to send various directives and commands to control the different UIU and CIU processes as well as control of the HH Carrier. The UIU also allows the operator to view numerous pages that monitor the health and safety for the customer payload, such as the current and temperatures. The UIU also performs hazardous command checks and telemetry limit checking. The UIU is also responsible for ingesting users commands via RS232/RS422 serial ports and sending the command packets to the CIU for output to the carrier.

The CIU is responsible for ingesting low rate telemetry from the HH carrier in the form of minor frames (I&T) or NASCOM blocks (mission), decommutating the data into subcom frames, and creating user data packets for distribution through the UIU to the customer. The CIU is also responsible for transmitting the commands to the avionics in I&T format (ground testing) or NASCOM format (mission operations). The CIU acts as a front end for the UIU.

The MRDU is a stand-alone medium rate processing system that ingests the 2MB composite data stream from the NASA Communications network (NASCOM), demultiplexes the customer medium rate data, and distributes that customer data via an RS422 interface to the CGSE. The MRDU is also responsible for archiving the 2MB composite data stream for use in creating the post-mission customer data products.

The ACCESS also has the capability of providing a real-time Data Display Unit (DDU) for each customer's use during a HH mission. The DDU's are stand-alone Windows-based PC's that display HH avionics health and safety data, as well as thermistor temperatures, customer data streams, and other telemetry and command status information. The pages displayed on the DDU contain the same information used by the ACCESS operators to monitor the HH avionics.

The thermal plotting capability is contained in a stand-alone workstation monitored by a thermal engineer during all HH missions. The system provides real time monitoring and near real time plots of the HH avionics and customer temperatures.

The following sections define the electrical interfaces supported by the ACCESS and the data transferred between the ACCESS and the CGSE.

Hitchhiker/Customer Communications

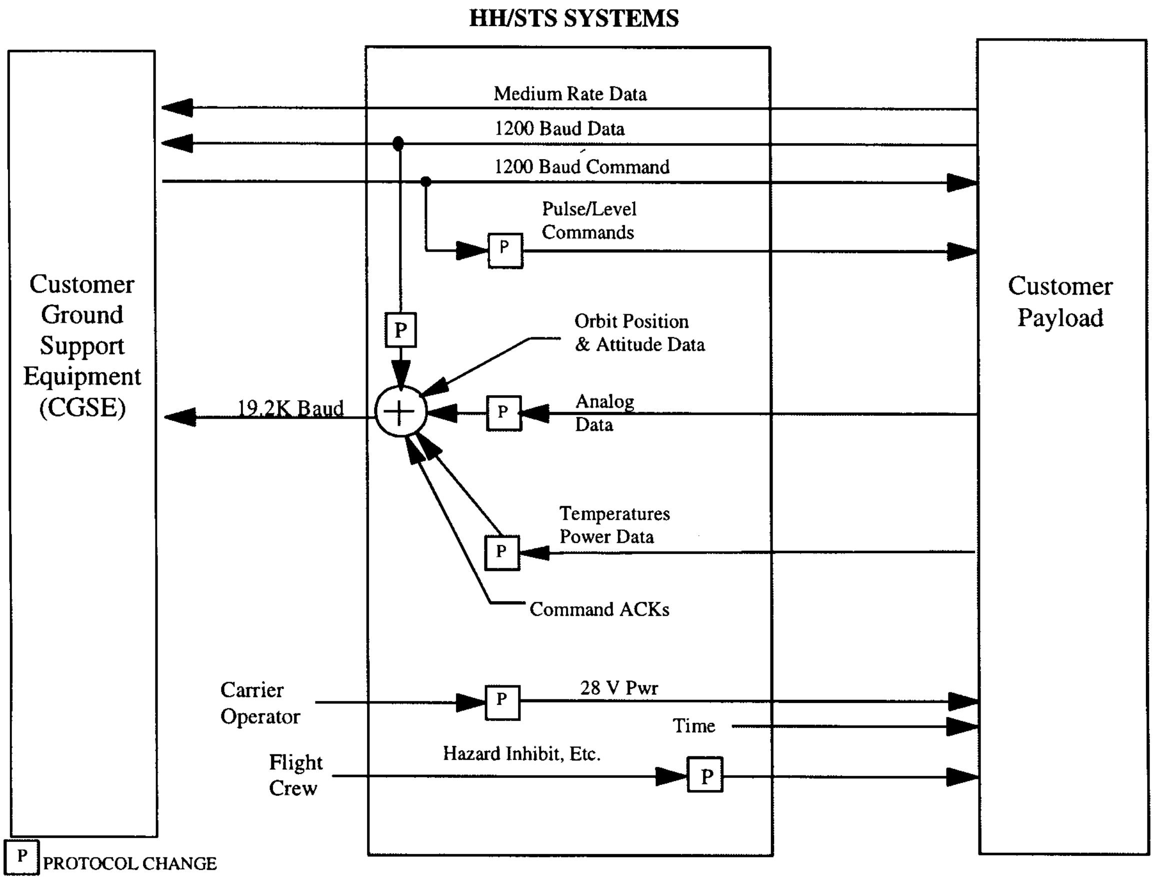


FIGURE 2.63 HITCHHIKER/CUSTOMER COMMUNICATIONS

Advanced Carrier Customer Equipment Support System (ACCESS)

Low Rate Data Processing

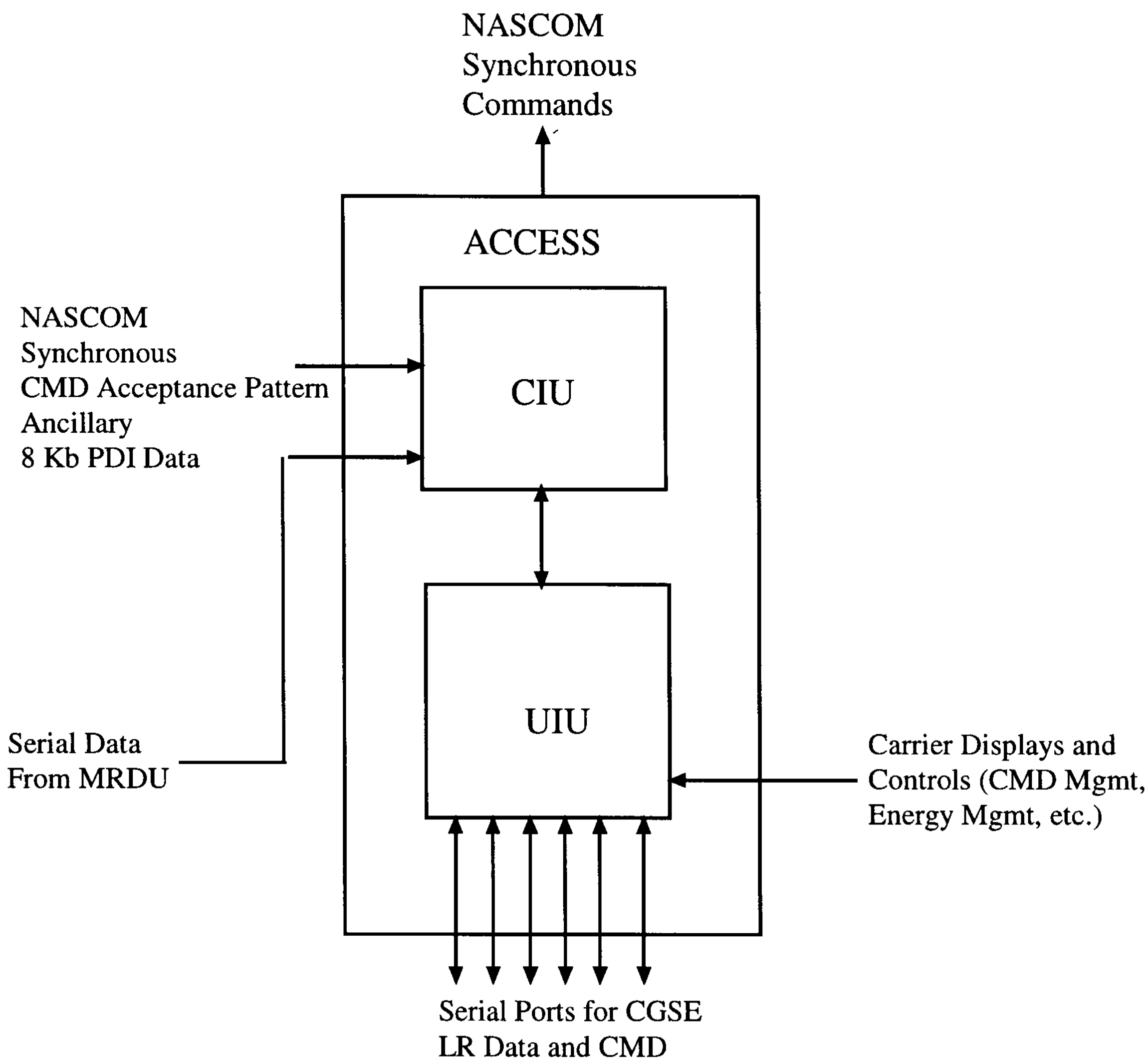


FIGURE 2.64 ACCESS LOW RATE DATA PROCESSING

Advanced Carrier Customer Equipment Support System (ACCESS)

Medium Rate Data Processing Unit (MRDU)

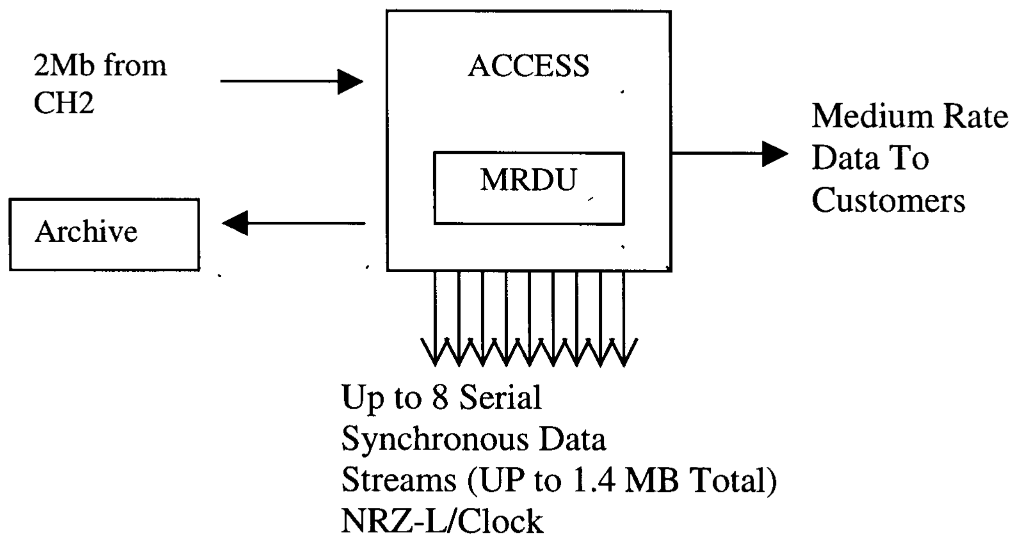


FIGURE 2.65 ACCESS MEDIUM RATE DATA PROCESSING UNIT

2.4.9.1 ACCESS-CGSE Physical Interface Requirements.

The asynchronous interfaces for customer unformatted payload telemetry (type 2) data and command generation are RS-232 or RS-422 compatible. These interfaces are full duplex with an ACCESS receive side for CGSE command messages and an ACCESS send side for transmitting customer data to the customer CGSE. One line (either RS-232 or RS-422) is assigned per customer ID (CID). The default data rate is 1200 baud (see Table 2.9 for additional line rates and information).

The asynchronous interfaces provided for HH ancillary data (type 4), formatted payload data (type 2), Shuttle orbit and attitude data (CAS – type 10), Analog data (type 3), Command Completion status messages (type 5), and Command Link status messages (type 6) are RS-232 compatible. These interfaces are half duplex and are not nominally used for command messages. The default rate is 19200 baud (see Table 2.9 for additional information).

A summary of the RS-232-C and RS-422 lines and their characteristics are presented in Table 2.9. The RS-232-C and RS-422 connector types and pin assignments are shown in Tables 2.10 and 2.11 respectively.

The interface for customer medium rate payload telemetry is RS-422 compatible. One line is assigned per customer ID (CID). The data rate is dependent on the number of customers using the HH avionics medium rate capability up to a combined rate of 1.2 Mb.

The medium rate connectors and pin assignments are shown in Table 2.12. A more detailed explanation of the telemetry and command interfaces are provided in the following sections.

TABLE 2.9 ACCESS - CGSE COMMUNICATIONS LINE

Line #	Line Characteristics	Function	Comments
1	Full Duplex, 1200 Baud, No Echo, 1 Start, 1 Stop, No Parity, RS422 Or RS232	Access Receive Side: CGSE Command Messages Access Send Side: Raw Payload Data From Avionics Asynchronous Send Data Port.	1 Line Per CID
2	Half Duplex, 19.2k Baud, No Echo, 1 Start, 1 Stop, No Parity, 8 Bit Data RS232	Multiplexed Data Messages Of Any Of The Following Types: 2 - Customer Async Data 3 – Customer Analog Data 4 – HH Ancillary Data 5 – Customer Command Completion 6 - Customer Command Link Status 10 - Shuttle Ancillary Data (Orbit/Attitude) 14 - Customer PCM-B Data 15 - Customer PCM-A Data	1 Line Per CID If Utilization Rate Exceeds 75% Of Baud Rate, A Second Line Will Be Required

TABLE 2.10 PIN DESIGNATION FOR RS-232 ASYNCHRONOUS DATA
(ACCESS to CGSE)
Serial Formatted Data
Unformatted Data
Avionics Ancillary Data
STS Orbit/Ancillary Data
Serial Command Messages (CGSE to ACCESS)

PIN Number	Function (Access)
1	Frame Ground (FG)
2	Transmit Data (TD)
3	Received Data (RD)
4-6	N/C
7	Signal Ground (SG)
8-25	N/C

The Serial Interface Circuit will use the "Null Modem" configuration, shown in Figure below.

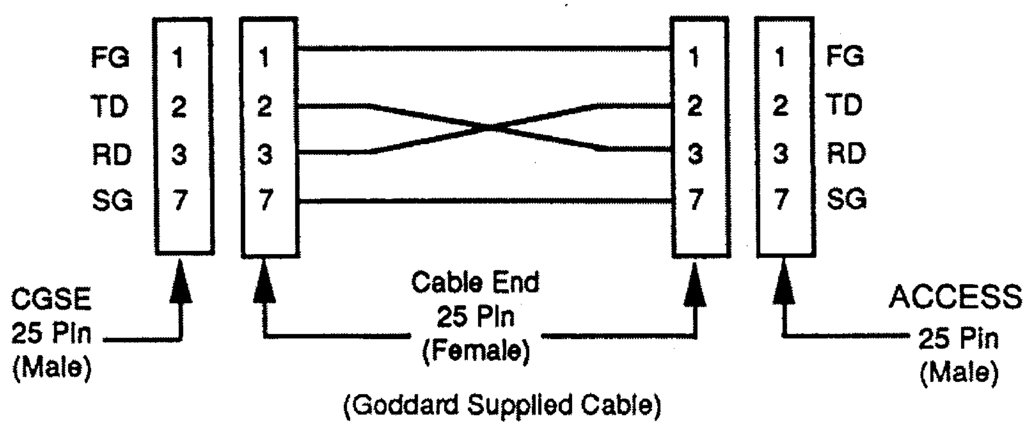


TABLE 2.11 PIN DESIGNATION FOR RS-422 ASYNCHRONOUS DATA
(ACCESS to CGSE)
Serial Formatted Data
Formatted Data
Serial Command Messages (CGSE to ACCESS)

Pin Number	Function	Comments
1	Frame Ground	Connector Type-
2	(+) Transmit Data	25-Pin Male
3	Signal Ground	Suggested Part
4	(-) Transmit Data	Sources
5	Signal Ground	(Male Connector)
6	(+) Receive Data	1. AMPHENOL
7	Signal Ground	P/N 0325PV
8	(-) Receive Data	2. TRW "Cinch"
9	Signal Ground	P/N DB-25P
10-25	N/C	or MIL-SPEC
		M24308/4-3

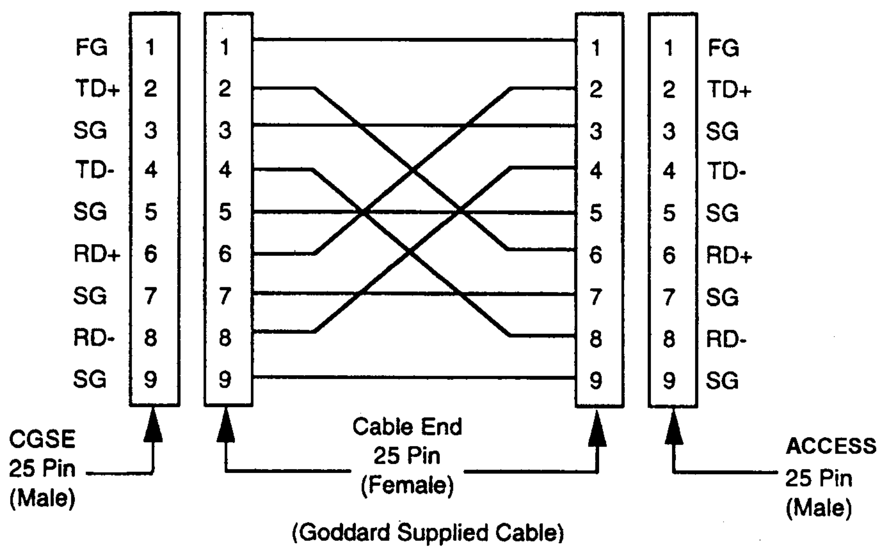
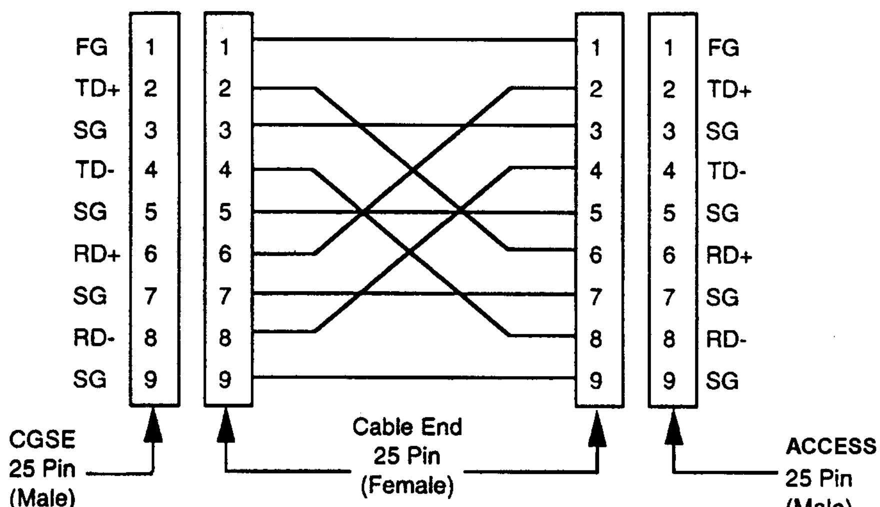


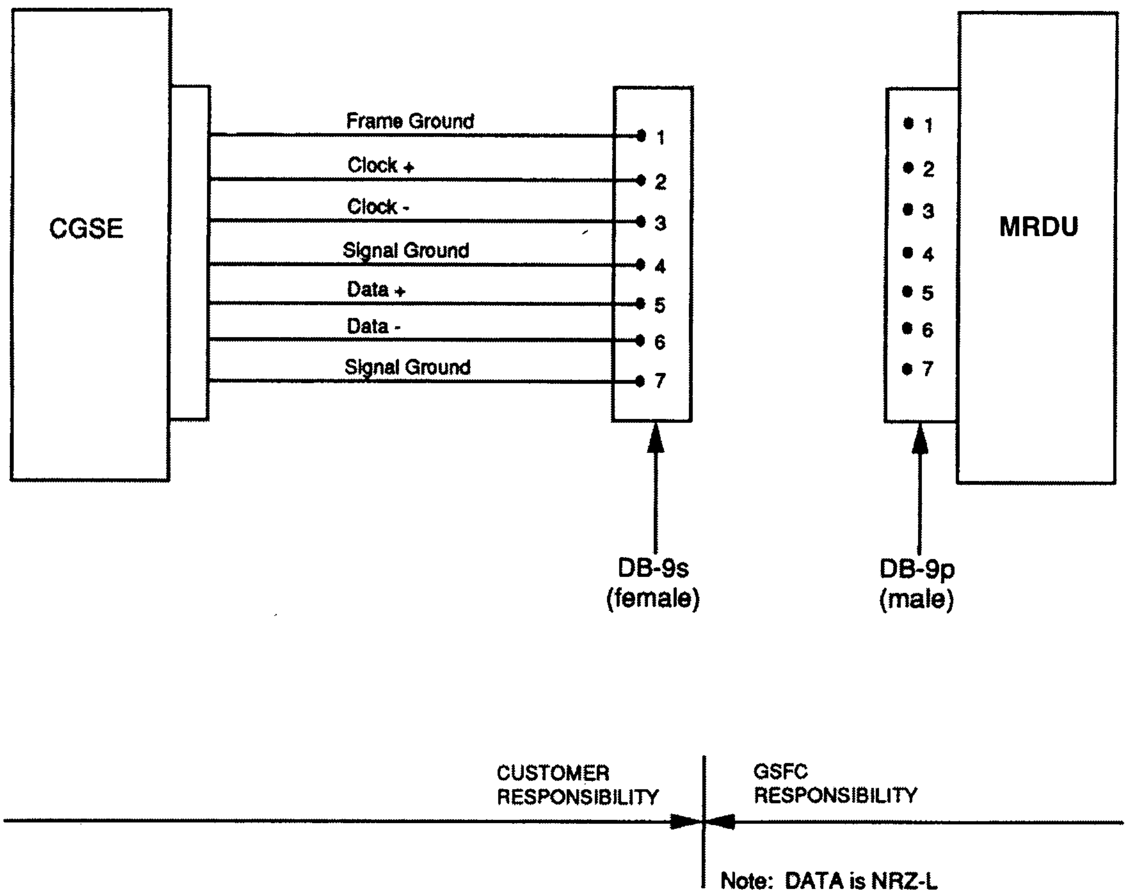
TABLE 2.11 PIN DESIGNATION FOR RS-422 ASYNCHRONOUS DATA
(ACCESS to CGSE)
Serial Formatted Data
Formatted Data
Serial Command Messages (CGSE to ACCESS)

Pin Number	**Function**	**Comments**
1	Frame Ground	Connector Type-
2	(+) Transmit Data	25-Pin Male
3	Signal Ground	Suggested Part
4	(-) Transmit Data	Sources
5	Signal Ground	(Male Connector)
6	(+) Receive Data	1. AMPHENOL
7	Signal Ground	P/N 0325PV
8	(-) Receive Data	2. TRW "Cinch"
9	Signal Ground	P/N DB-25P
10-25	N/C	or MIL-SPEC
		M24308/4-3



(Goddard Supplied Cable)

TABLE 2.12 PIN DESIGNATION FOR CUSTOMER RS-422 MEDIUM RATE DATA
Ground Data Interface
(ACCESS to CGSE)



NOTE: Suggested Cable length is 30 feet.

2.4.9.2 ACCESS-CGSE Telemetry Interface

The ACCESS can provide HH avionics telemetry and asynchronous payload telemetry to the CGSE. No data interpretation or conversions are performed by the ACCESS. All data of a given type are transferred in a time-sequential order. The following sub-sections describe the format of the data transferred.

1. Unformatted Customer Payload Asynchronous Downlink Data (Type 2)

The customer will receive the asynchronous payload telemetry in near real-time in a "transparent" manner. The data are bursted to the CGSE over a dedicated 1200-baud asynchronous telemetry/command line (RS-232-C or RS422) without any framing, as they are received by the ACCESS. No attempt is made to synchronize this stream with any other data stream or to maintain the data sampling timing relationship within a stream.

2. Formatted Customer Asynchronous Downlink Payload Data (Type 2)

The ACCESS formatted messages contain a maximum of 120 bytes of payload data and contain the HH time code of the telemetry frame containing the last data byte transmitted within the message. This data message format is shown in Table 2.13. The ACCESS schedules transmission of these blocks upon the filling of the data fields within the message or after one second if the message is not empty. If these messages are multiplexed with other message blocks, the timing between messages is erratic. Note that it is possible to receive a block with "no data bytes" if a sync error is encountered.

The customer will receive the formatted asynchronous payload data in near real time over an ACCESS/CGSE line. The electrical interface is nominally a 19.2 baud RS-232-C data line. The ACCESS will place the payload data into individual messages. No attempt is made to synchronize the data within the messages.

The ACCESS can also send the HH avionics ancillary data, customer energy data, analog data, command acknowledgments, and a subset of the Shuttle orbit and attitude data multiplexed with the formatted asynchronous payload data.

The aggregate data rate of all the multiplexed data (including overhead) must not exceed 75 percent of the data line baud rate. Whenever the data rates are predicted to exceed the 75 percent threshold, another RS-232-C line will be provided. In this case, the assignment of data types transferred over each line will be negotiated with the Project. The user may reconstruct each data stream by grouping data of similar types.

TABLE 2.13 ACCESS FORMATTED ASYNCHRONOUS DATA MESSAGE STRUCTURE

Byte	Bits	Function	Content
1	1-8	Synchronization	E5 (Base 16)
2	1-8	Number of data bytes in message	$0 \leq N \leq 120$
3	1-4	Customer Identification (CID)	$1 \leq CID \leq 8$
3	5-8	Message type	2
4-5	1-8/1-8	Binary day of MET from Avionics PCM frame containing last payload data byte (DD)	$0 \leq DD \leq 366$
6-9	1-8/1-8	Milliseconds of day from Avionics PCM frame containing last payload data byte. Treated as a 32-bit integer (M)	$0 \leq M \leq 86399999$
10	1	Avionics minor frame sync loss indicator 1 = sync loss during data collection	0/1
10	2	MCU frame sync loss indicator 1 = sync loss during data collection	0/1
10	3	MCU encountered data overrun if set to 1	0/1
10	4	MCU encountered parity error if set to 1	0/1
10	5-8	Spare	0'S
10+N	1-8	Payload data	0-255
11+N	1-8	Exclusive OR of bytes 2 through (N+10)	0-255

3. Customer Analog Data (Type 3)

The customer may receive data from its analog channel assigned by the HH mission. The ACCESS formats the data into message blocks as shown in Table 2.14. The data are tagged with the HH time code (MET) of the minor frame containing the last byte of user data transmitted within the message. No attempt is made to synchronize the data within the sequence of analog samples. This message is scheduled for transmission to the CGSE every HH major frame. It is multiplexed with other ancillary and command acknowledgment messages, hence the timing between the messages is erratic. However, the time for messages of the same time is in ascending order.

TABLE 2.14 ACCESS FORMATTED PAYLOAD ANALOG DATA STRUCTURE

Byte	Bits	Function	Value
1	1-8	Synchronization	E5(Base 16)
2	1-8	Number of data bytes in message	32
3	1-4	Customer Identification (CID)	$1 \leq \text{CID} \leq 8$
3	5-8	Message type	3
4-5	1-8/1-8	Binary day of year from Avionics PCM frame containing last byte of multiplexer data transferred (DD)	$0 \leq \text{DD} \leq 366$
6-9	1-8/1-8/ 1-8/1-8	Milliseconds of day from Avionics PCM frame containing last byte of analog data transferred (M)	$0 \leq \text{M} \leq 86399999$
10	1	Avionics minor frame sync loss during data collection if set	0/1
10	2-8	Spare	0
11-42	1-8	Analog data	0-255
43	1-8	Exclusive OR of bytes 2-42	0-255

4. HH Ancillary Data Message (Type 4)

The ACCESS will provide HH avionics ancillary data messages which contain information such as the payload temperatures, relay states, current load, user analog data, and energy usage. The frequency and content of this message is dependent upon the mission-unique HH telemetry format. Currently, the message is transmitted approximately once every 4 seconds assuming a nominal 8kb/sec telemetry rate. The format of the HH ancillary data messages is defined in Table 2.15. The time field is the HH time code of the minor frame from which the last data byte was sampled.

TABLE 2.15 ACCESS ANCILLARY DATA MESSAGE STRUCTURE

Byte	Bits	Function	Content
1	1-8	Synchronization	E5 (Base 16)
2	1-8	Number of data bytes in message	10
3	1-4	Customer Identification (CID)	$1 \leq CID \leq 8$
3	5-8	Message type	4
4-5	1-8/1-8	Binary day of year	$0 \leq DD \leq 366$
6-9	1-8/1-8/ 1-8/1-8	Milliseconds of day	$0 \leq M \leq 86399999$
10	1	HH minor frame sync loss indicator (1=Loss)	0/1
10	2	MCU sync loss indicator (1=Loss)	0/1
10	3	Avionics analog channel sync loss (1=Loss)	0/1
10	4-8	Spare	0
11	1-8	Current drawn by user in counts (as telemetered)	0-255
12	1-8	Relay status as telemetered	0-255
13	1-8	Heater bus status	0-255
14	1-8	Thermistor #1 reading in counts	0-255
15	1-8	Thermistor #2 reading in counts	0-255
16	1-8	Thermistor #3 reading in counts	0-255
17	1-8	Energy usage as computed by MCU in counts (Sample 1)	0-255
18	1-8	Bus voltage as sampled by MCU in counts (sample 1)	0-255
19	1-8	Energy usage as computed by MCU in counts (sample 2)	0-255
20	1-8	Bus voltage as sampled by MCU in counts (sample 2)	0-255
21	1-8	Exclusive OR of bytes 2-20	0-255

5. Shuttle Orbit and Attitude Data Messages (Type 10)

The customer may receive the Shuttle orbit and attitude parameters as they are received by the ACCESS from the Calibrated Ancillary System (CAS) at the Johnson Space Center (JSC). No attempt is made to convert the data values. The time field is contained in the Shuttle ancillary data block received from the CAS. Table 2.16 depicts the default format and content of the message. The frequency of the message is approximately once a second. The customer may negotiate with the Project for the inclusion of other data found in the Shuttle ancillary data block.

Algorithms for converting the quaternions in these messages to RA/DEC of the Z axis or orbiter R,P,Y angles are given in Appendix G.

TABLE 2.16 SHUTTLE ORBIT AND ATTITUDE DATA MESSAGE STRUCTURE

Byte	Bits	Function	Value
1	1-8	Synchronization	E5 (Base 16)
2	1-8	Number of data bytes in message, excluding header and checksum	92
3	1-4	Customer Identification (CID)	$1 \leq CID \leq 8$
3	5-8	Message type	10
4-5	1-8/1-8	Binary day of year computed from Primary Source MET	$0 \leq DD \leq 366$
6-9	1-8/1-8/ 1-8/1-8	Milliseconds of day computed from Primary Source MET	$0 \leq M \leq 86399999$
10	Spare		
11-18	All	X-Component of current Shuttle position vector in IBM floating point. M50 coordinate system.	
19-26	All	Y component of current Shuttle position vector IBM floating point. M50 coordinate system.	
27-34	All	Z component of current Shuttle position vector in IBM floating point M50 coordinate system.	
35-38	All	X component of velocity vector in IBM floating point. M50 coordinate system.	
39-42	All	Y-component of velocity vector in IBM floating point. M50 coordinate system.	
43-46	All	Z component of velocity vector in IBM floating point. M50 coordinate system.	

TABLE 2.16 CONTINUED

47-54	All	Time Tag associated with current state in IBM floating point.
55-58	All	M50 to measured body quaternion element 1 in IBM floating point
59-62	All	M50 to measured body quaternion element 2 in IBM floating point
63-66	All	M50 to measured body quaternion element 3 in IBM floating point
67-70	All	M50 to measured body quaternion element 4 in IBM floating point
71-74	All	M50 WRT LVLH quaternion element 1 in IBM floating point
75-78	All	M50 WRT LVLH quaternion element 2 in IBM floating point
79-82	All	M50 WRT LVLH quaternion element 3 in IBM floating point
83-86	All	M50 WRT LVLH Quaternion Element 4 in IBM floating point
87-102	All	Vernier Jet Data
103	1-8	Exclusive OR of bytes 2-102

TABLE 2.16 CONTINUED

VERNIER JET DATA

Bytes 87-102

Up to 16 Samples of Orbiter Vernier Thruster Data in Time Sequence

Bit 1 = 0 Valid Sample
Bit 1 = 1 Fill (No valid sample)

Bit 2 Spare

Bits 3-8 Vernier Jet Data
1 = Jet Firing
0 = Jet Not Firing

BIT	JET	POSITION	PLUME DIRECTION
3	F5L	FWD-Left	Down/Left
4	F5R	FWD- Right	Down/Right
5	L5D	AFT-Left	Down
6	L5L	AFT-Left	Left
7	R5R	AFT-Right	Right
8	R5D	AFT-Right	Down

TABLE 2.16 CONTINUED

VERNIER JET DATA

Bytes 87-102

Up to 16 Samples of Orbiter Vernier Thruster Data in Time Sequence

Bit 1 = 0 Valid Sample
Bit 1 = 1 Fill (No valid sample)

Bit 2 Spare

Bits 3-8 Vernier Jet Data
1 = Jet Firing
0 = Jet Not Firing

BIT	JET	POSITION	PLUME DIRECTION
3	F5L	FWD-Left	Down/Left
4	F5R	FWD- Right	Down/Right
5	L5D	AFT-Left	Down
6	L5L	AFT-Left	Left
7	R5R	AFT-Right	Right
8	R5D	AFT-Right	Down

2.4.9.3 ACCESS-CGSE Command Interfaces

Messages are exchanged between the ACCESS and CGSE for payload commanding and command acknowledgment.

The ACCESS UIU will accept commands from the CGSE over a 1200 baud RS-232-C or RS-422 interface. These commands will be screened by the ACCESS for criticality, then transferred to the ACCESS CIU via the LAN. Once a customer's command is received at the CIU, it is placed in a command block, encoded in the proper format (NASCOM or I&T) and placed into an uplink command buffer, then transmitted. The CIU will verify that the command block was accepted by the HH avionics. A new command block will not be transmitted until a previously transmitted command block is verified by the HH avionics in telemetry. Commands that are not verified within a timely manner (nominally 5 seconds for I&T, and 15 seconds during mission operations) by the HH avionics will be retransmitted by the ACCESS operators. The command will not be released from the ACCESS buffer until a verification has been received from the avionics. ACCESS, however, does not monitor the telemetry to determine if the customer payload responded to the commands.

Customer CGSE's are connected to the ACCESS via the Serial Port Interfaces referenced in Figure 2.63. This places some limitations on user command thru-put, especially for long "back to back" experiment command strings.

In reference to the HH Command Flow, the following three elements apply:

1. The presence of a 1200-baud ACCESS line does not mean that the user can continuously pump commands at this rate. The maximum command string length is 119 bytes. User minimum Delay Time (DT) between command strings sent by its CGSE to the ACCESS is:

   DT = (Number of active command lines) * (400 milliseconds).

2. The ACCESS UIU uses message queues for transferring user commands to the ACCESS CIU via the LAN. It takes the UIU 400 milliseconds to encode the user input command for transfer it to the CIU. It will take twice as long, on average, to process two user input buffers. If a user does not enforce a delay of DT milliseconds between long command strings, an overflow can occur causing customer commands to be lost.

Command string staging is of significant overhead for the ACCESS. Suggested average separation between long strings of Universal Asynchronous Receiver Transmitter (UART) commands with two active command lines is 800 milliseconds.

The user is advised to hold its long command strings in its own CGSE for DT time rather than using the ACCESS to stage its long command strings.

3. Note that the ACCESS "round-robin" prioritization of users can improve the ACCESS processing of long and short command strings generated by two concurrent users.

2.4.9.4 ACCESS Command Acknowledgment (ACKS) Messages (Types 5/6)

These messages are multiplexed with the HH system ancillary data messages, Shuttle orbit and attitude data messages, etc. All messages are optional. These messages are transmitted from the ACCESS to the CGSE on the 19.2k baud link. The time in these two messages is the ACCESS computer GMT time when the message was generated.

1. Command Completion Status (Type 5)

After transmission by the ACCESS, the ACCESS issues an optional command acknowledgment message to the CGSE indicating the number of commands successfully transmitted to the HH avionics. Upon receipt of this message, the CGSE may issue another set of commands. If the CGSE does not opt for the command completion message, the CGSE should verify the receipt of the commands by the payload prior to transmitting more commands. Failure to do so may result in the loss of commands because the command link is slower than the aggregate command rate of all the users. In fact, transmission delays of 10-20 seconds may be common in operations because of additional delay in the networks and MCC. The format of this message is shown in Table 2.17.

TABLE 2.17 ACCESS COMMAND COMPLETION STATUS MESSAGE STRUCTURE

Byte	Bits	Function	Value
1	1-8	Synchronization	E5 (Base 16)
2	2-8	Number of data bytes in the message, excluding header and checksum	2
3	1-4	Customer Identification (CID)	$1 \leq CID \leq 8$
3	5-8	Message type	5
4-5	1-8/1-8	Binary day of year	$1 \leq DD \leq 366$ (Note 1)
6-9	1-8/1-8/ 1-8/1-8	Millisecond time of day	$0 \leq M \leq 86399999$
10	1-8	Spare	0
11	1-8	Number of commands transmitted	
12	1-8	Number of commands accepted by SPOC	
13	1-8	Exclusive OR of bytes 2-12	0-255

Note 1: This time is the ACCESS computer GMT time.

2. Data Link Status (Type 6)

The ACCESS will originate messages if errors are detected in the command data link between the ACCESS and the CGSE. The messages indicate the error and the number of commands rejected by the ACCESS because of the error. The format of this message is shown in Table 2.18.

TABLE 2.18 ACCESS DATA LINK STATUS MESSAGE STRUCTURE

Byte	Bits	Function	Value
1	1-8	Synchronization	E5 (Base 16)
2	2-8	Number of data bytes in message, from bytes 11 to end not including check sum	2
3	1-4	Customer Identification (CID)	$1 \leq \text{CID} \leq 8$
3	5-8	Message Type	6
4-5	1-8/1-8	Binary day of year	$1 \leq \text{DD} \leq 366$ (Note 1)
6-9	1-8/1-8/ 1-8/1-8	Millisecond time of day (M)	$0 \leq M \leq 8639999$
10	1-8	Spare	0
11	1-8	Number of command bytes accepted or rejected	$1 \leq M \leq 120$
12	1-8	Status indicator (no bits set = received CMD without errors)	
	Bit #1	- CGSE shipped too many bytes in command message	
	Bit #2	- Parity error in transmission between CGSE-ACCESS	
	Bit #3	- Data overrun	
	Bit #4	- Framing Error	
	Bit #5	- Invalid CID	
	Bit #6	- Checksum Error	
	1-8	Exclusive OR of bytes 2 through 12	0-255

Note 1: This time is the ACCESS computer GMT time.

2.4.10 Crew Control

The Crew Control system provides a second method (independent of the ground command system) for controlling the flow of power to the customer payloads and, thus, ensures that power could be removed from the payload even in the event of any single failure. Since two independent commands (crew and ground) are required to apply power to a customer payload, two inhibits are present to prevent a hazardous payload function from occurring during ascent or descent. Additional crew control functions can be used to inhibit a hazardous payload function during on-orbit operations.

Crew Control of the carrier power system (see Figure 2.34) is implemented using the first two switches S1 and S2 (DS1 and DS2 indicate the state of S1 and S2) of the SPASP or normally the first two switches of the SSP (see Figure 2.68). The carrier can be assigned to either half of the SSP and if assigned to the other half, S13 and S14 (DS13 and DS14 indicate the state of S13 and S14) would be used. The remaining switches can be assigned to a customer function with a negotiated electrical interface. Switch panel control is normally provided only to inhibit a hazardous function or provide a crew controlled function which must be synchronized with some other crew activity such as Orbiter attitude control. The use of the SPASP or SSP is determined by NASA based on the STS manifesting rules. The available switch and indicator characteristics are shown in Figure 2.69. The SSP cargo switching and fusing interface schematic is shown in Figure 2.70 (sheet 1 & 2).

2.4.11 Undedicated Connections in Standard Interface

Some Twisted Shielded Pair (TSP) and single wires in each interface are undedicated and may be connected by mission unique jumper plugs to the following:

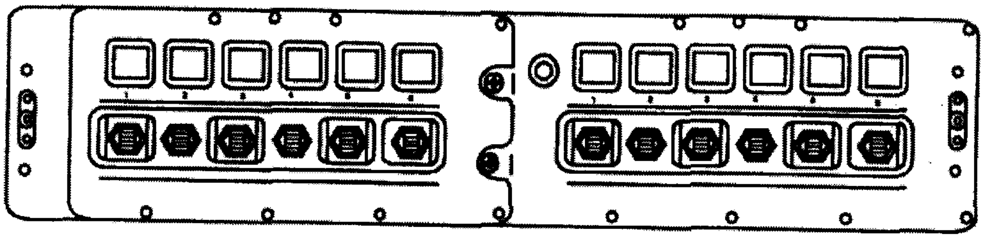
1. Crew Control (Switch Panel)

2. Undedicated wires in a second standard interface port assigned to the same customer.

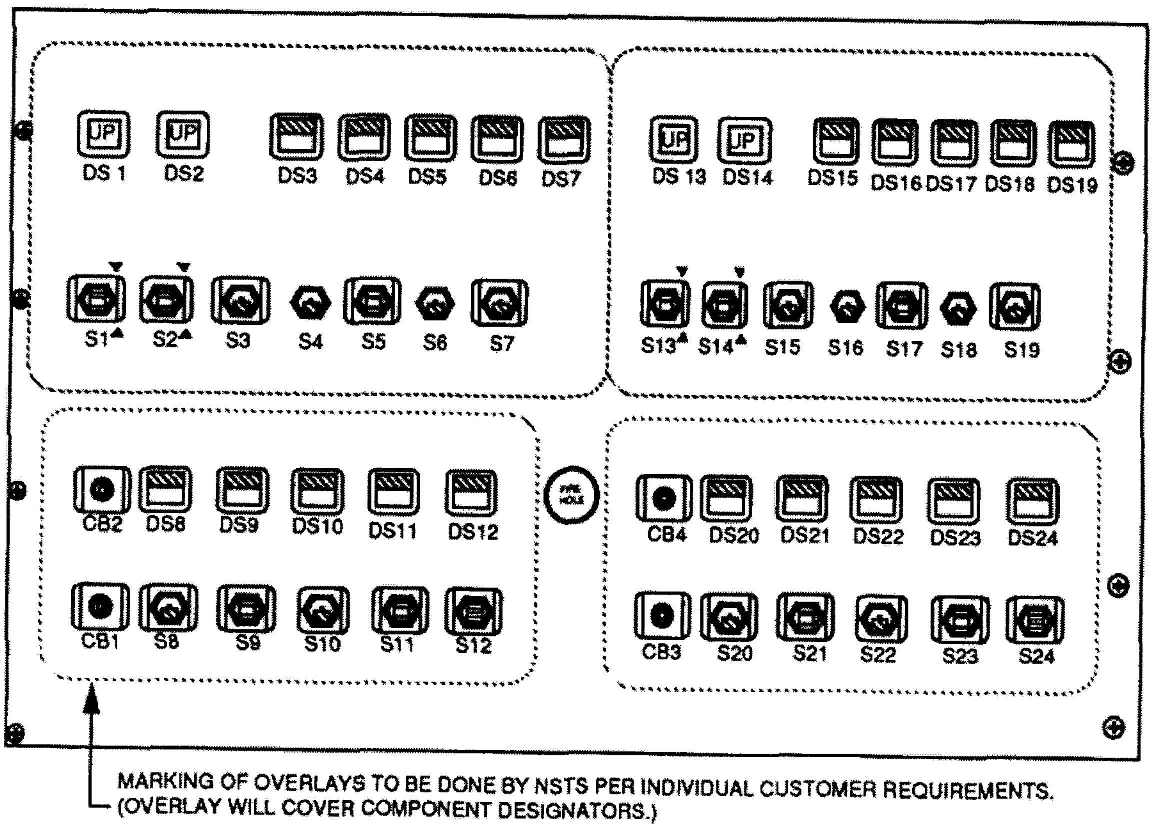
3. Other function as negotiated.

Use of the special connections may result in conflicts between customer payloads on the same flight and may therefore reduce manifesting possibilities and flight opportunities for each customer.

Switch Panels



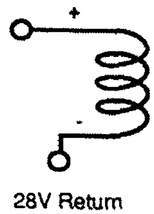
SMALL PAYLOAD ACCOMMODATION SWITCH PANEL (SPASP)
S1, S2, DS1, DS2- RESERVED FOR CARRIER USE



STANDARD SWITCH PANEL (SSP)
S1, S2, DS1, DS2 OR S13, S14, DS13, DS14 RESERVED FOR CARRIER USE

FIGURE 2.65 SWITCH PANELS

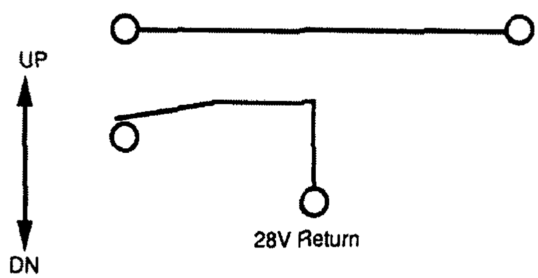
SPASP or SSP Switch and Indicator Characteristics



Coil Resistance
28.0 ± 3 K Ω

On = Gray = 18 to 32 VDC
Off = Stripes = 0 to 5 VDC

SPASP or SSP Mechanical Indicator



SPASP Switch (TYP 6 Places)

Resistance: 5 Ω MAX
Maximum Current: 1 AMP (dc only)
Minimum Current required to drive indicator:30 ma
Maximum Voltage: 32 VDC
Total available for customers: 4 (SPA), 10 (SMC)

FIGURE 2.66 SPASP OR SSP SWITCH AND INDICATOR CHARACTERISTICS

SSP Cargo Element Switching And Fusing Interface Schematic (Sheet 1 of 2)

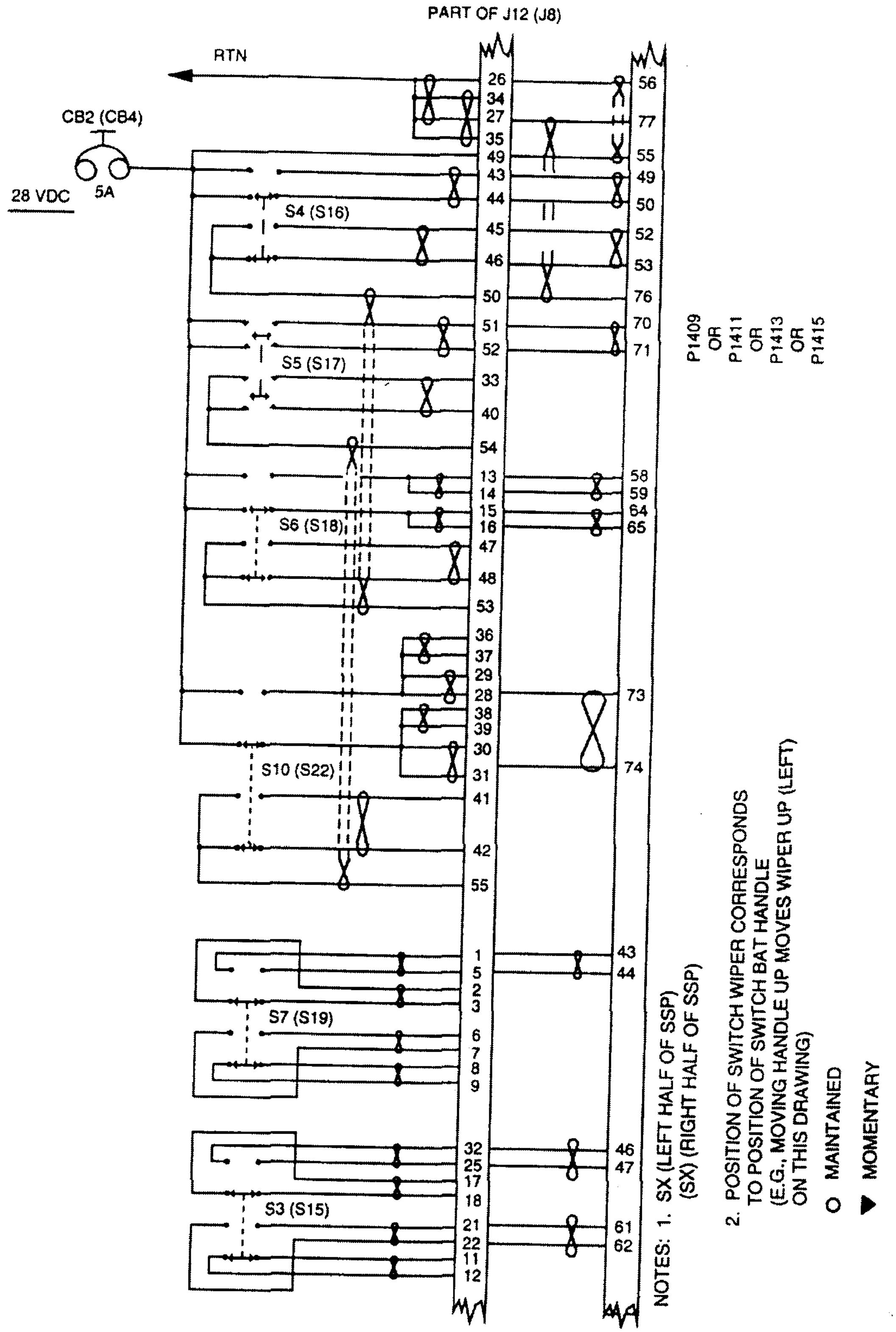


FIGURE 2.67 SSP CARGO ELEMENT SWITCHING AND FUSING INTERFACE SCHEMATIC (1OF 2)

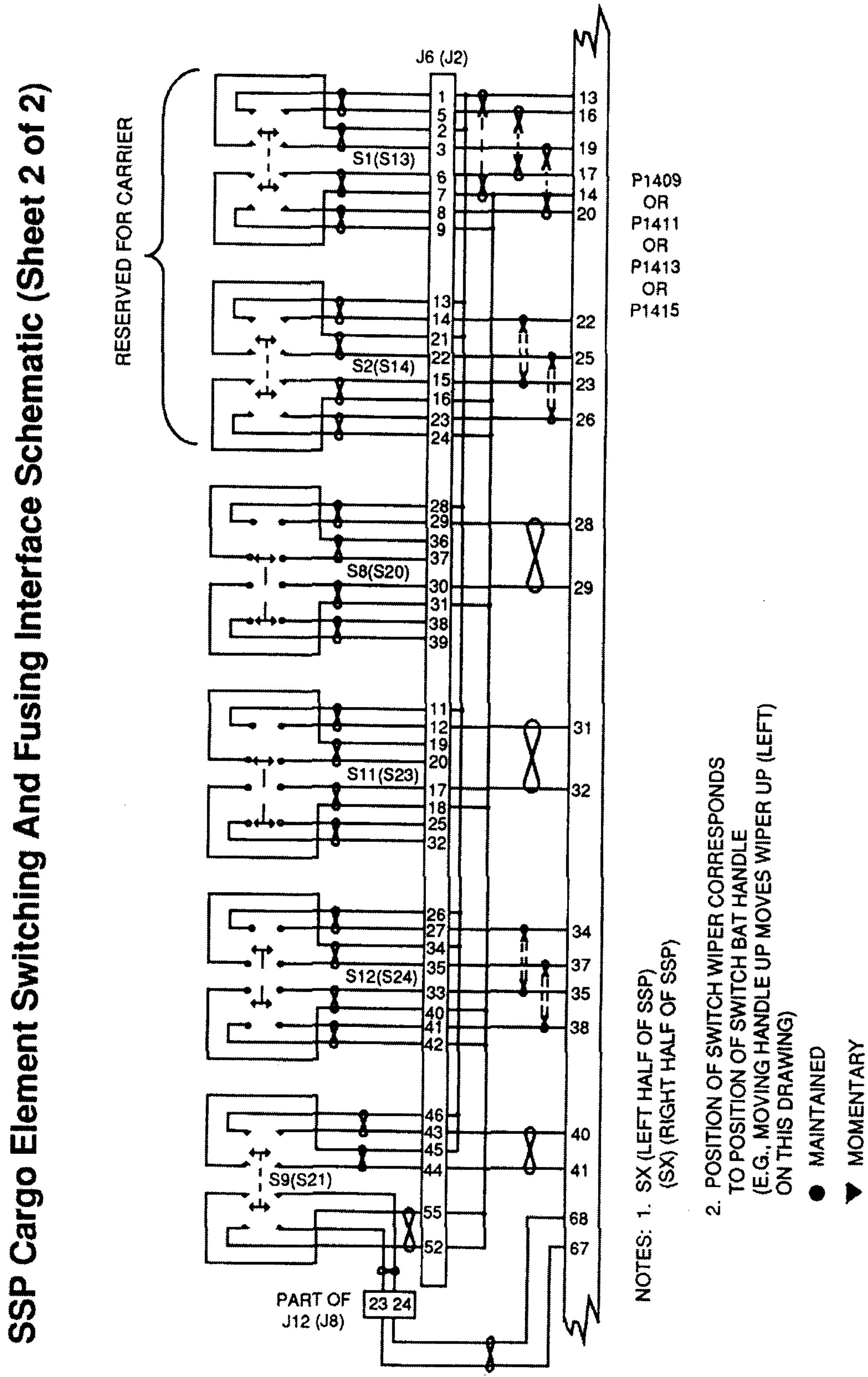


FIGURE 2.68 SSP CARGO ELEMENT SWITCHING AND FUSING INTERFACE SCHEMATIC (2 OF 2)

2.4.12 Orbiter CCTV Interface

A special interface can be provided to allow the display of a customer payload generated TV signal in the crew cabin. This signal can also be recorded on-board or transmitted to the ground. The signals are standard National Television Standard Committee (NTSC) (EIA RS-170/RS-330) color or black and white television signals transmitted on a differential interface. Details of the CCTV interfaces and services can be provided by the project office.

2.4.13 Hitchhiker Video Interface Unit

The Hitchhiker Video Interface Unit (HVIU) is Hitchhiker-provided. Video can be accommodated from eight separate customer signal ports, one at a time. Switching of HVIU channels is commanded via ACCESS. The HVIU produces a differential signal output to the orbiter CCTV interface.

Customer video input to the HVIU shall be an unbalanced, 75-ohm interface and shall conform to RS-170 and RS-330 specifications. Shield shall be tied to frame ground at the customer side; the video signal lines shall be isolated from frame ground by at least 1 Mohm. Therefore, use of commercially available devices which tie signal ground to chassis should be avoided.

During the mission, availability of real-time video telemetry depends on orbiter support of payload CCTV and cannot be guaranteed. However, payload video can be recorded via the orbiter recorders and replayed at a later time during the mission or provided post-mission. Therefore, customers whose video is critical to their experiment are advised to consider incorporating recording capability in their hardware design.

2.5 Hitchhiker-JR (HH-J)

2.5.1 Hitchhiker-JR Overview

The HH-J carrier provides mechanical and electrical interfaces similar to the existing GAS carrier which has been used in the past to carry Shuttle secondary payloads. Following availability of the new carrier, the GAS carrier will not be used for secondary payloads.

The new avionics system (Figures 2.72 - 2.74) provides for better monitoring of carrier functions and can provide improved monitoring and power services for customer equipment if desired.

The HH-J carrier system consists of a canister (with or without a motorized door) equipped with a HH Remote Interface Unit (HRIU). The HRIU communicates via a control line with a Payload and General Support Computer (PGSC) in the crew cabin. The PGSC is a lap top class personal computer and contains payload unique software provided by SSPP.

The HH-J avionics is operated from Orbiter power unlike the GAS avionics which is battery operated. Orbiter power may also be used for heaters and can be used to operate customer equipment if certain restrictions are met. Customer equipment may also be operated from customer supplied batteries if desired.

During flight operations, the crew controls HH-J and GAS payloads using a menu type control and display interface on the PGSC. Unlike the avionics used with GAS, the HRIU reports carrier status information for display to the crew. The status information includes canister temperature and pressure, customer battery voltage and current, door status, and commanded relay status. This information will help SSPP, the customer, and flight crew make decisions during the flight. On some missions it will be possible to record the status data in the laptop periodically for post flight use. Each HRIU has a unique data bus address allowing the crew to individually communicate with a number of HH-J canisters.

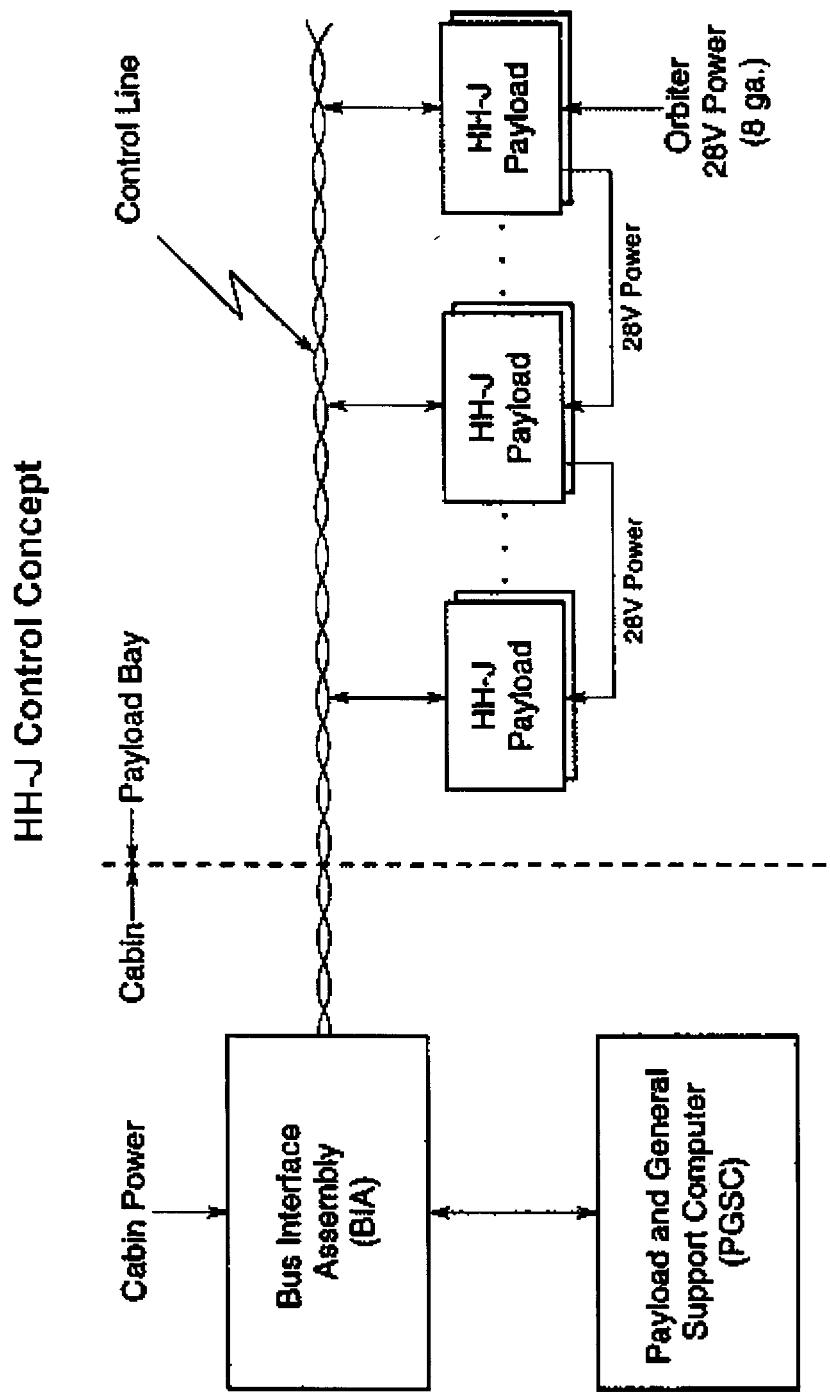


FIGURE 2.69 HH-J CONTROL CONCEPT

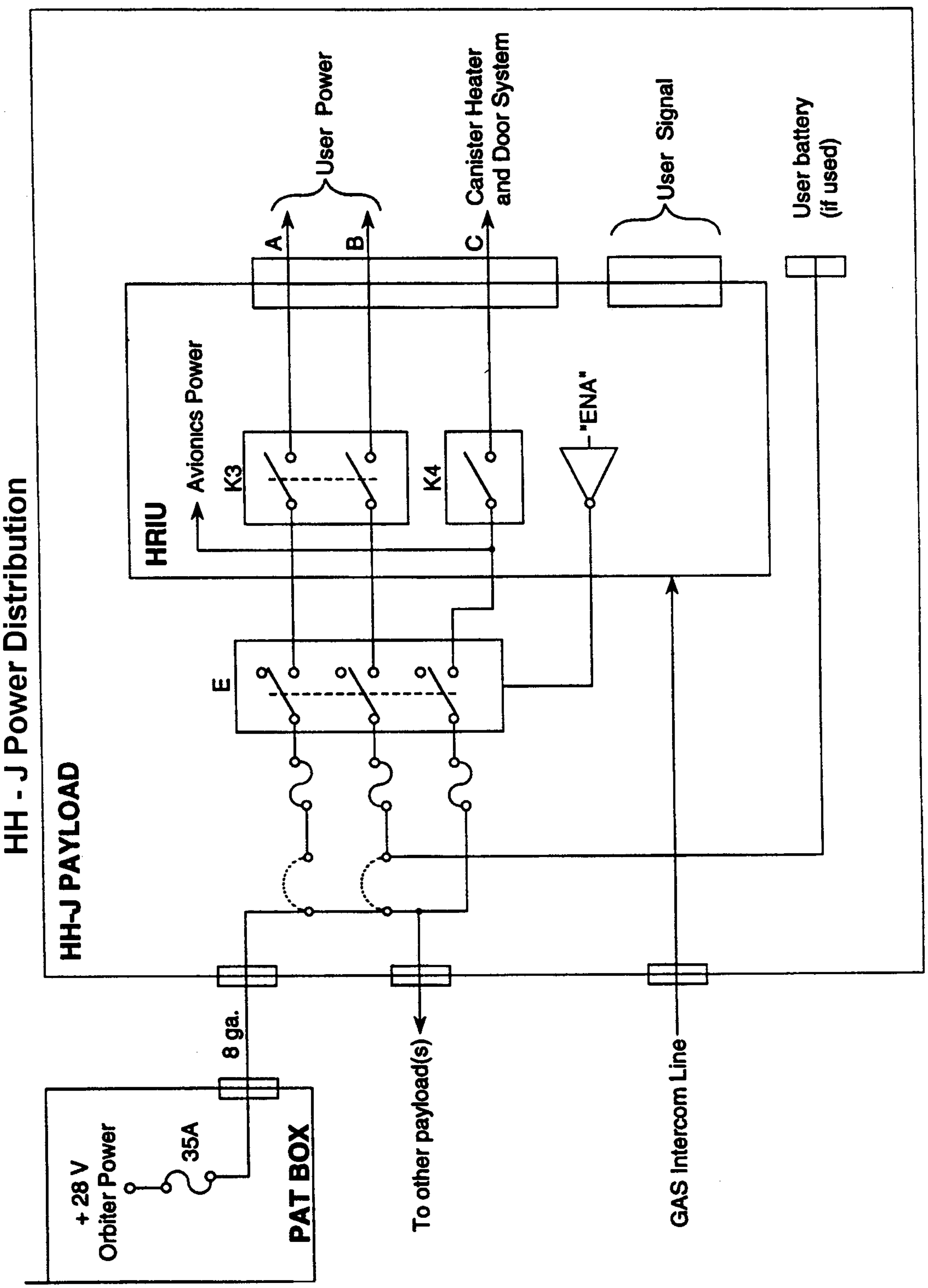


FIGURE 2.70 HH-J POWER DISTRIBUTION

If the customer desires and provides the necessary wiring, it is possible to provide the crew with some displays of customer hardware status.

Customer mechanical interfaces are the same as for the standard HH canister (section 2.1.1.). HH-J canisters may be flown on the side-mount or bridge configuration.

2.5.2 Hitchhiker-J Electrical Interfaces

2.5.2.1 HH-J Electrical Power

HH-J customer equipment may be operated from Orbiter power or from internal customer batteries with power switched by carrier relays in a manner similar to GAS as shown in Figure 2.70. If internal power is used, the carrier provides two size 12 power wires individually protected by 20 amp fuses in the carrier and switched by a crew controlled relay. Customer peak power should be limited to a maximum of 10 amps in either line because of vacuum derating of the fuses.

The enable relays ("E") in all the canisters are simultaneously activated by the crew near the beginning of the mission and deactivated near the end of the mission. The "E" relays are controlled by a single switch on the Bus Interface Assembly (BIA) in the cabin and are independent of the computer for safety reasons. The "E" relays provide power to the HRIUs in the canisters. Once the HRIUs are activated, the crew can individually activate the "K3" relay (to provide power to the customer equipment) and the "K4" relay (controlling canister heater and door power) in any specific canister.

The HRIU is provided with a current monitor which measures the total current in the A, B, and C power lines. The HRIU also measures the voltage on the down stream side of the K3 and K4 relays.

The customer may elect to use Orbiter +28 VDC power. In this case, maximum power draw of the equipment is limited to 100 watts and the energy use over the duration of the mission is limited to a maximum of 4 Kwh. The customer equipment must meet the requirements of section 2.3.1 with regard to power voltage, conducted electromagnetic noise emitted by the customer equipment, ground isolation, and susceptibility of customer equipment to Orbiter generated electromagnetic noise. Orbiter power is normally available starting several hours after payload bay doors are opened and extended to several hours prior to payload bay door closing.

2.5.2.2 HH-J Control Relays

The HRIU has two control relays "K1" and "K2" which may be used to control customer equipment. The relays are limited to 1 Amp and 32 volts and are break-before-make single pole double throw type. The nominal launch configuration of all relays is "reset".

2.5.2.3 HH-J Thermistors

The user may elect to place SSPP supplied temperature sensors in his equipment wired to the customer interface connector. The characteristics of the sensors are given in section 2.2.2. The use of the sensors will improve crew monitoring of significant temperatures in customer equipment.

2.5.2.4 HH-J Analog Telemetry Data

The user may elect to connect internal status measurements to carrier analog telemetry inputs which allow crew monitoring of a voltage between zero and +5 volts. A single measurement may be connected to the PCMAD signal line as defined in section 2.4.7.1. Also, an index pulse, PCMINDX, may be used to step a customer's internal multiplexer as described in section 2.4.7.1. For HH-J, only infrequent sampling of the data is possible. Contact the Project Office for more information.

2.5.2.5 HH-J Bi-level or Pulse Commands

Bi-level commands may be set to OV (false), or to +28V (true), or pulsed from false to true and back to false. (It is preferred to have the bi-level transverse from false to true, default state is OV for HRIU) All commanding of bi-level functions is performed by the mission specific Flight Software (FSW), which is developed at GSFC, and executed on the Payload & General Support Computer (PGSC). Four bi-levels are available to each customer. Only one bi-level signal may be commanded by the FSW at a time. A minimum of 100msec is required between each bi-level command. Figure 2.71 illustrates the HH-J bi-level command electrical interface.

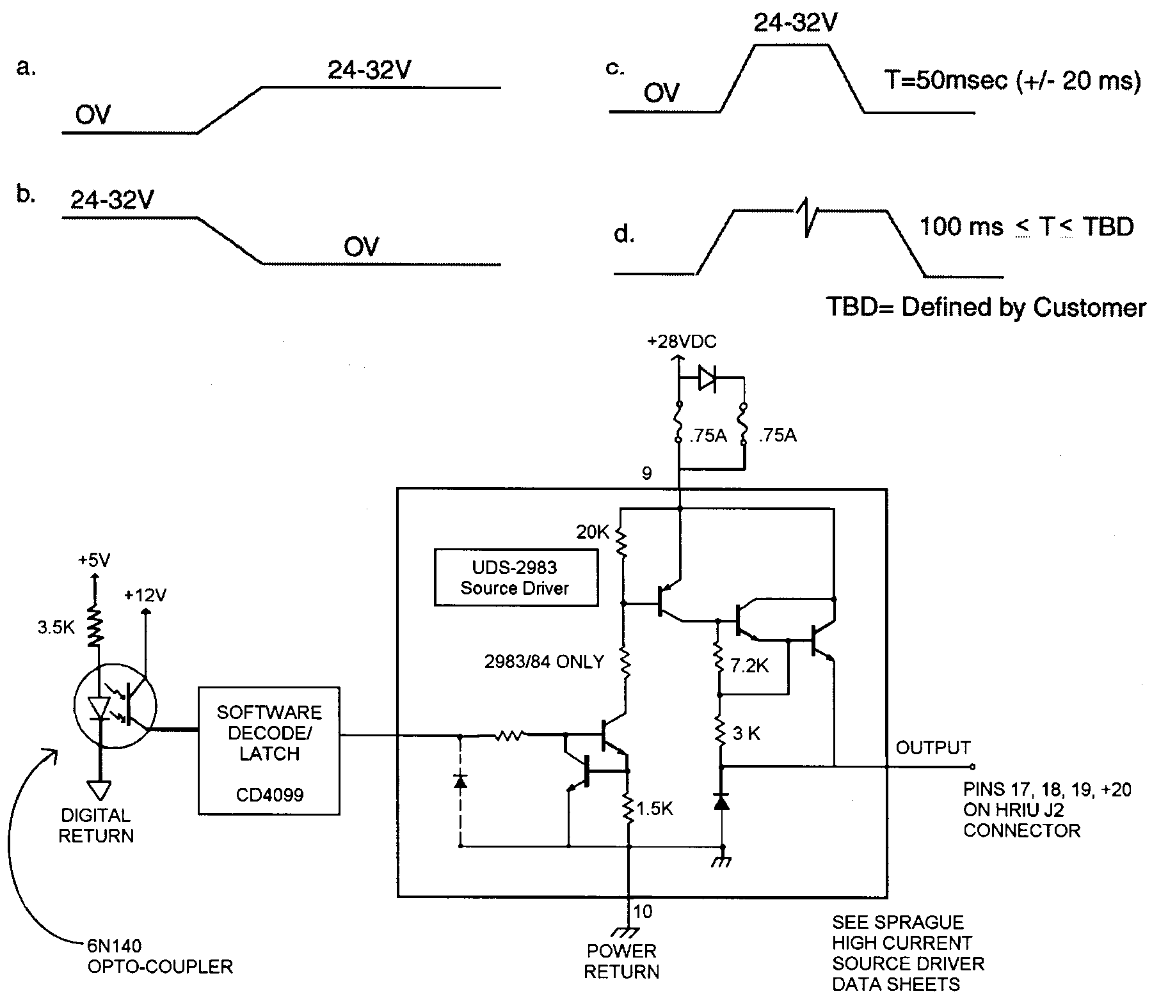


FIGURE 2.71 HH-J BI-LEVEL COMMAND ELECTRICAL INTERFACE

2.5.2.6 HH-J Customer Connectors

The HH-J canister bottom plate contains connectors for connecting customer equipment designated J13, J2, and J11 as shown in Table 2.21. J13 provides the Orbiter power interfaces, J2 provides signal interfaces, J11 connects to a connector on the canister bottom plate and can be used for ground test connection to customer equipment after it has been installed in a canister or for connecting two adjacent canisters during flight using an optional interconnect cable. An additional connector, J12 is used in place of J13 if the customer equipment contains its own battery. The Project Office will furnish connectors to the customer for use in fabricating the customer to carrier cables.

2.5.2.7 HH-J Grounding

The customer equipment return for Orbiter 28VDC power is Orbiter power return. If the customer provides his own battery power, the battery voltage may not exceed 32 VDC and the battery negative terminal should be connected to frame (structure) ground in the customer equipment. Orbiter power return connection in customer equipment using Orbiter power must be isolated from frame ground by a minimum of 10 K Ohms resistance. Orbiter power return is connected to frame ground in the Orbiter.

The reference for analog signals, thermistor returns, and PCMINDX signal is carrier signal ground. The signal ground must be isolated from frame ground and Orbiter 28 V return by a minimum of 10 K ohms unless a project waiver is obtained. Signal ground is connected to frame ground in the carrier.

2.5.2.8 HH-J Electromagnetic Interference Control

HH-J customer equipment must meet the requirements of Appendix H.

2.5.2.9 HH-J Thermal Control

Customer equipment may contain heater(s) and thermostat(s) connected to the 28V Orbiter heater power lines (+28HTR, RETH) controlled by commandable relay K4 and not exceeding a maximum of 50 watts (for all heaters on simultaneously at 32 volts). Thermostats should not be set to a temperature higher than 5 degrees C unless approved by the Project Office.

2.5.2.10 HH-J Malfunction Inputs

Two of the thermistor inputs, THER1 and THER2, may instead be used as malfunction inputs. Malfunction inputs on HH-J are similar but not identical to the functions in the GAS carrier. A user may provide a "true" malfunction input to cause the carrier to reset the power relay in the carrier and remove power from the instrument. A malfunction true condition is indicated by an input voltage between zero and 2.0 volts relative to circuit ground, or by a resistance of less than 100 ohms between the malfunction input and circuit ground. A malfunction false condition is indicated by an input voltage between 3.5 volts and 5.0 volts or an input resistance higher than 100K ohms.

If a malfunction true condition is sensed at either of the malfunction inputs for 2 seconds or more, the HH-J carrier software will reset the power relay. The relay will remain reset unless set by the flight crew. The values of the malfunction input voltages are available for display to the crew in the Orbiter cabin.

The equivalent circuit for the malfunction input in the carrier is the same as for the thermistor input shown in Figure 2.69.

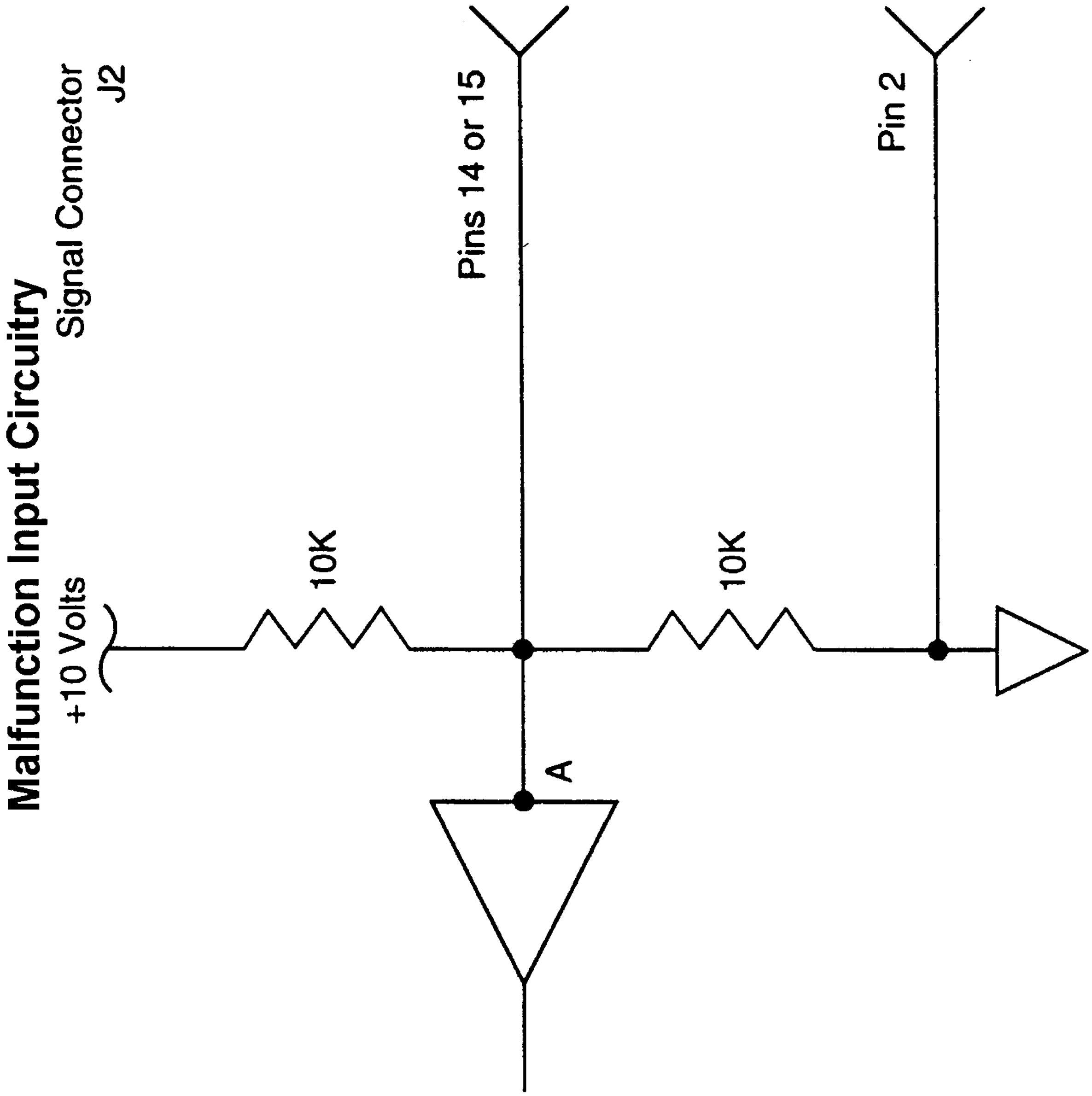


FIGURE 2.72 MALFUNCTION INPUT CIRCUITRY

TABLE 2.20 HITCHHIKER-JR ELECTRICAL INTERFACE CONNECTIONS

Power Connector P13 (Orbiter Power)

Customer Connector Type: CVA6R20-15PN-16

ID	PIN	TYPE	FUNCTION
+28	A	C	+28 Power Circuit A
RETA	B	C	Power Return (Note 1)
+28B	C	C	+28 Power Circuit B
RETB	D	C	Power Return (Note 1)
+28HTR	E	B	+28 Heater Power
RETH	F	B	Heater Power Return (Note 1)
FRMGND	G	B	Frame Ground

Signal Connector P2

Customer Connector Type: KJG6E18-35PN-16

PCMAD	1	A	Analog Data, O - +5v
PCMINDX	41	A	Index Pulse
SIGGND	2	A	Signal Ground
SHIELD	6	A	Shield (To Be Tied To Frame Ground In PLD)
BLCMD1	17	A	Bi-level/Pulse Command 1
BLCMD2	18	A	Bi-level/Pulse Command 2
BLCMD3	19	A	Bi-level/Pulse Command 3
BLCMD4	20	A	Bi-level/Pulse Command 4
THER1	14	A	Thermistor 1 Or Malf Input #1
THER2	15	A	Thermistor 2 Or Malf Input #2
THER3	16	A	Thermistor 3
K2RES	58	A	K2 Relay Reset Contact
K2SET	57	A	K2 Relay Set Contact
K2ARM	59	A	K2 Relay Arm
K1RES	49	A	K1 Relay Reset Contact
K1SET	56	A	K1 Relay Set Contact
K1ARM	50	A	K1 Relay Arm

Safe/Arm Or Interconnect Connector P11

Customer Connector Type: TVSO6RF-21-16S(453)

ID	PIN	TYPE	FUNCTION
	A	B	
	B	B	
	G	B	
	R	B	
	N	B	
	C	B	
	J	F	
	H	F	
	P	F	
	D	F	
	L	F	
	K	A	Twisted Shielded Pair TSP1+
	F	A	TSP1-
	E	A	TSP Shield
	M	A	TSP2+
	S	A	TSP2-

Power Connector P12 (Battery Power)

Customer Connector Type: JTO6RE-16-6S

BATA+	A	C	CUSTOMER BATTERY + CIRCUIT A
BATB+	B	C	CUSTOMER BATTERY + CIRCUIT B
PPWRA	C	C	CUSTOMER LOAD CIRCUIT A
PPWRB	D	C	CUSTOMER LOAD CIRCUIT B
+28HTR	E	B	ORBITER 28V HEATER POWER
RETH	F	B	HEATER POWER RETURN

Note 1: Power Return Pins B, D May Be Connected Together Within Payload.

Note 2: Wire Type Designation:

TYPE	SIZE
A	22 GA
B	16 GA
C	12 GA
F	20 GA

See Fusing Requirements In Table 2.6.

Note 3: Customer Will Make No Connections To Unused Pins

2.6 *Hitchhiker Ejection Capabilities Specification*

The Hitchhiker carrier system provides several options for launching a small spacecraft from the Shuttle payload bay. Figure 2.75 shows a typical payload configuration. Each option requires the same maximum payload weight and CG offset and same user-supplied 9.37 inch interface plate, which attaches to the carrier with a clamp mechanism. Figure 2.76 describes this interface plate with some reference dimensions. Detailed requirements for this plate are contained in the most current revision of GD 1507205, Ejection System User Interface Control Drawing. None of the launch configurations provides any electrical power or signal connection to the spacecraft, but each provides a different satellite envelope and payload environment. The five different payload configurations listed below are shown in Figures 2.77 to 2.81.

PAYLOAD CONFIGURATIONS

Hitchhiker Ejection System (HES): always mounted in a canister.
1. with an opening door
2. with no door (open-top canister)

Pallet Ejection System (PES): canister-mounted configuration.
3. with an opening door
4. with no door (open-top canister)

Pallet Ejection System (PES): pallet-mounted configuration.
5. on top of cross-bay structure

Payload and ejection system are mounted either in a canister or on a pallet prior to orbiter installation and launch. The user must provide means for lifting the spacecraft during installation on to the ejection system. For a canister-mounted satellite, only the top of the payload will be accessible for servicing after it is installed into the canister.

Once in orbit with the Shuttle in the requested attitude, the clamp is released by the crew and the payload is ejected. The system does not provide for controlled rotation (spin) of the payload prior to ejection, but a worst case ejection torque applied about the ejection vector will be calculated for every mission. This torque is dependent on several factors. Orbital lifetime of ejected objects in typical Shuttle orbits is usually less than one year.

Spacecraft must be designed to avoid contact with the canister under launch loads and during ejection.

The ejection system and door mechanism are zero fault tolerant against a failure that would cause inability to eject or inability to close the door. Therefore, the spacecraft design must satisfy Shuttle safety requirements for a landing in the Shuttle with the door open. Spacecraft with hazardous functions that occur after ejection (such as deploying appendages) must provide adequate safety inhibits to prevent premature activation. Payloads with such functions are strongly advised to set up a Technical Interchange Meeting (TIM) with the SSPP system safety organization.

Users must select an ejection attitude and velocity that preclude any possibility of collision with the Shuttle during the portion of the mission following satellite deployment. JSC will perform a re-contact analysis to insure that no re-contact occurs.

Table 2.23 lists some characteristics and requirements of HH launcher systems. Deviations from these or other ejection system requirements are negotiable on a case-by-case basis. For example, a larger CG offset may be acceptable for a physically smaller satellite.

TABLE 2.21 CHARACTERISTICS OF HITCHHIKER LAUNCHER SYSTEMS

Maximum spacecraft weight	150 lb (68 kg)
Maximum spacecraft CG offset from separation plane	10.25 in (26 cm)
Maximum spacecraft CG offset from launcher centerline	0.25 in (0.64 cm)
Ejection velocity range	1 to 4 ft/sec (0.3 to 1.2 m/sec)

EJECTION SYSTEM OVERVIEW

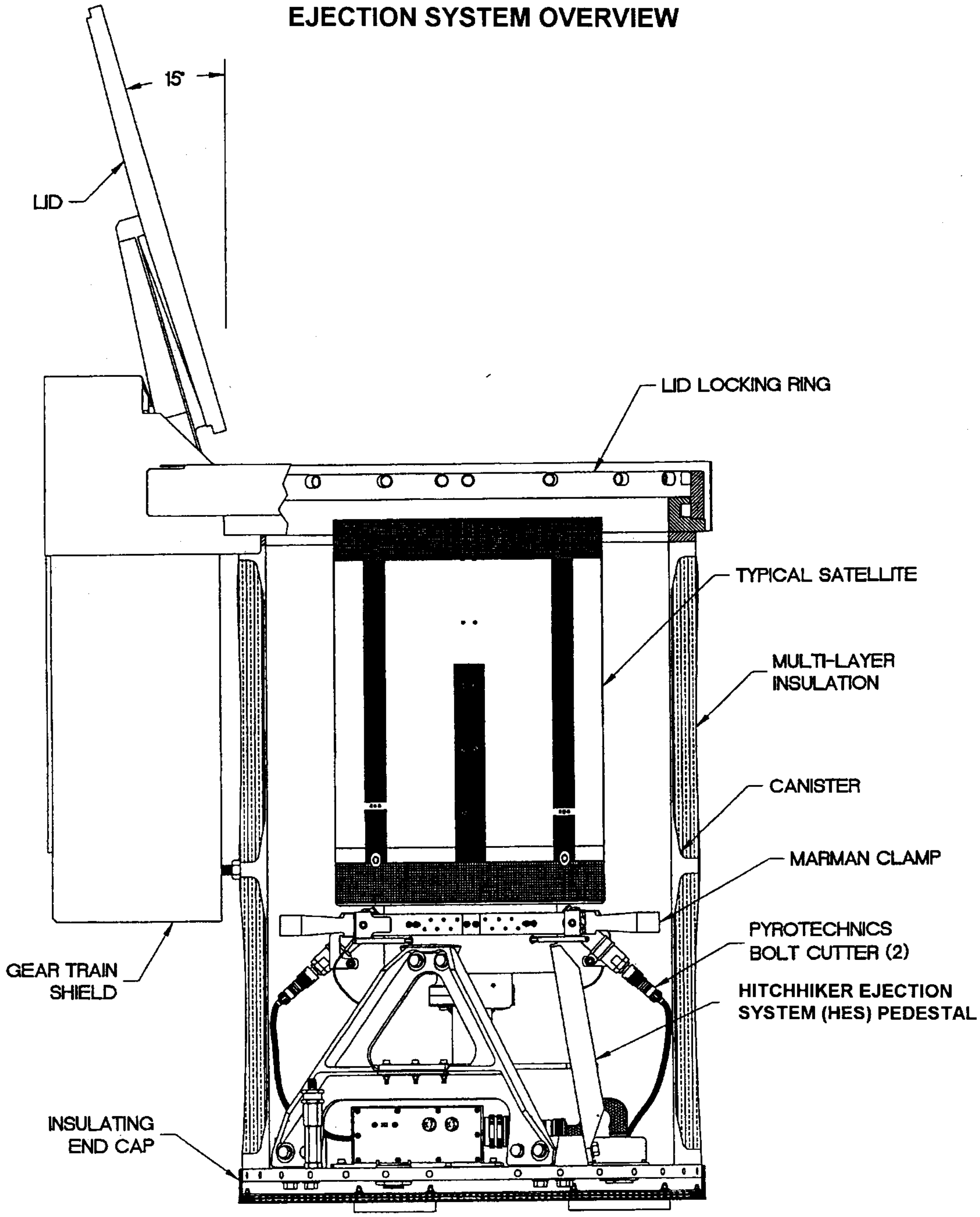


FIGURE 2.73 EJECTION SYSTEM OVERVIEW

PAYLOAD INTERFACE PLATE

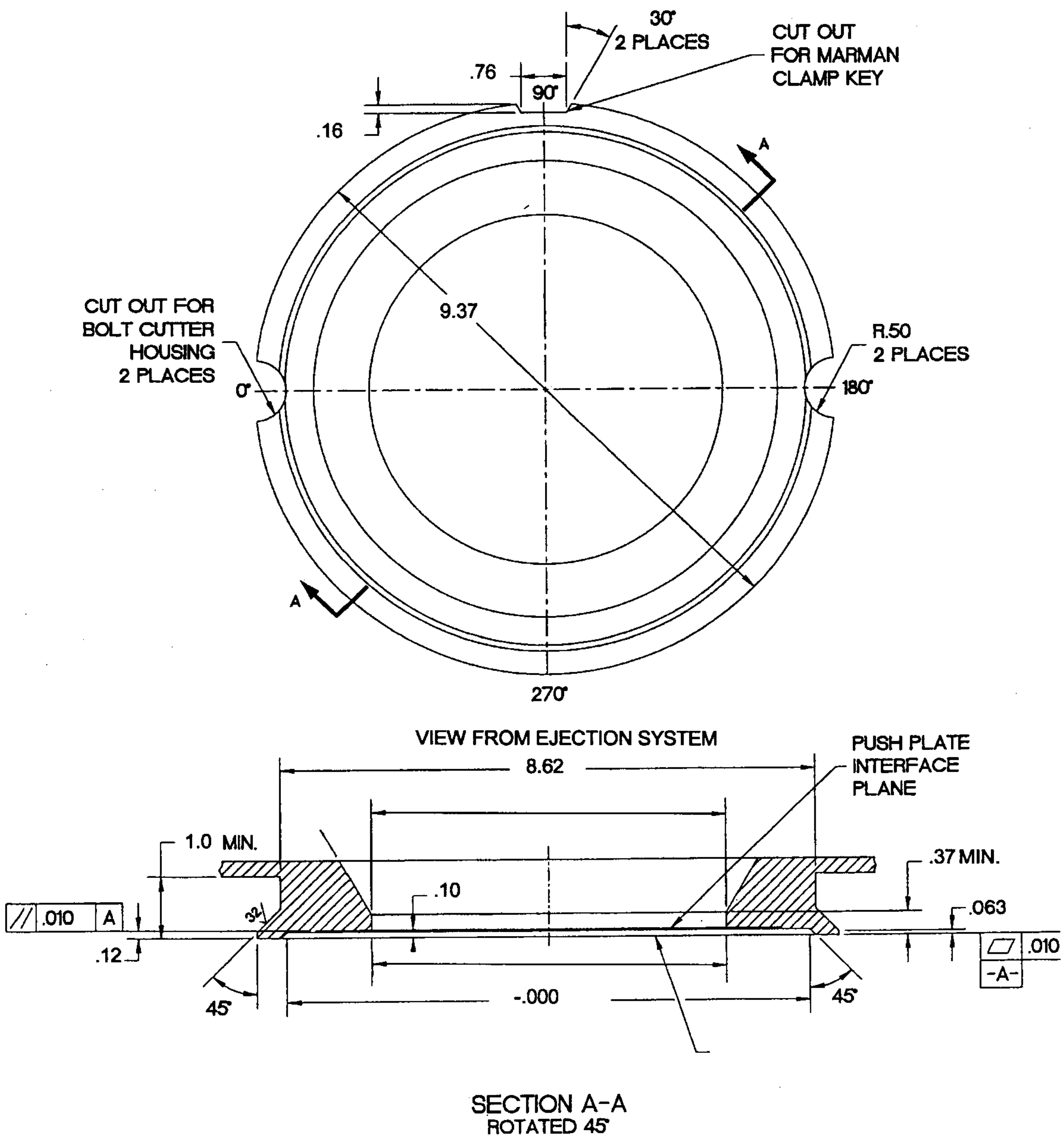


FIGURE 2.74 PAYLOAD INTERFACE PLATE

HITCHHIKER EJECTION SYSTEM WITH DOOR

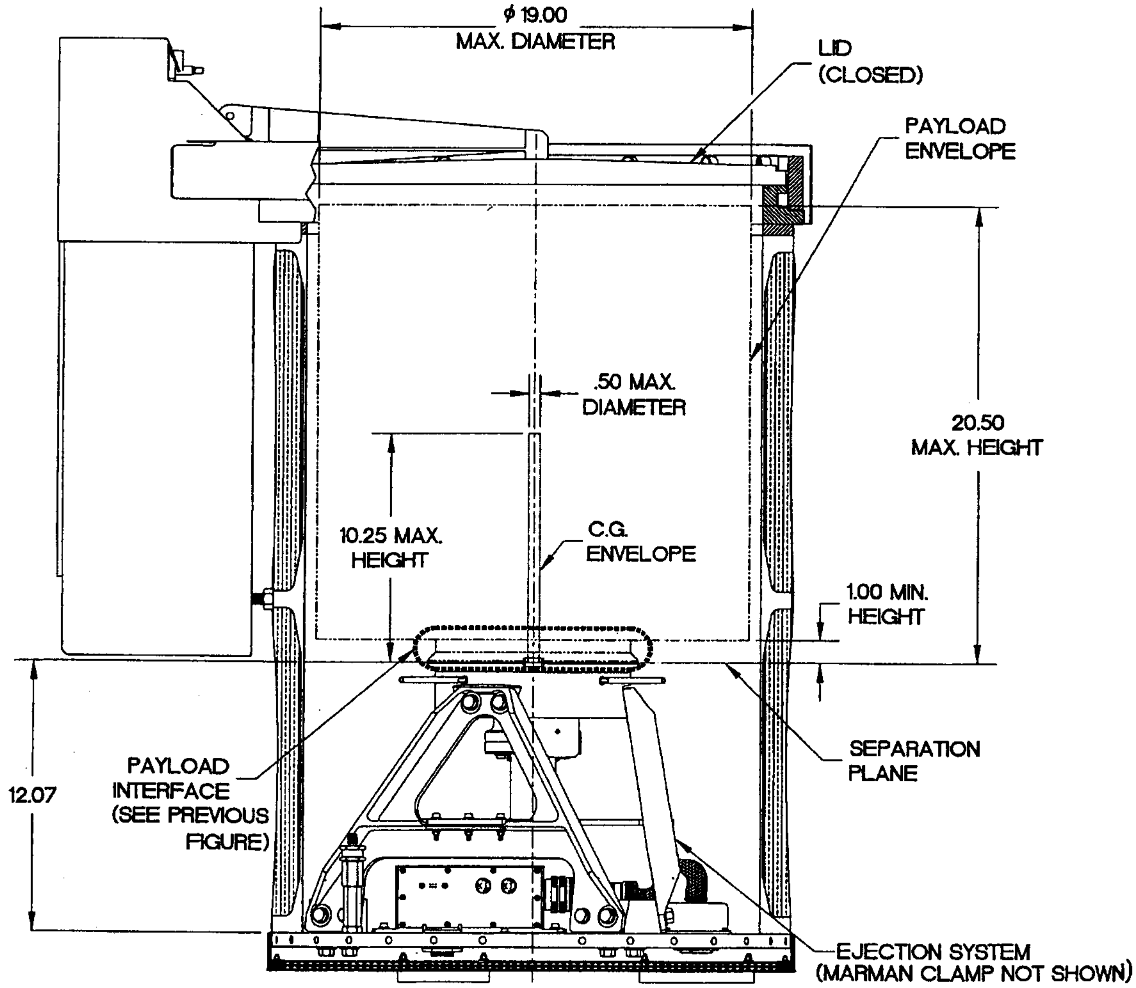


FIGURE 2.75 HITCHHIKER EJECTION SYSTEM WITH DOOR

HITCHHIKER CARRIER EJECTION SYSTEM WITH OPEN CANISTER

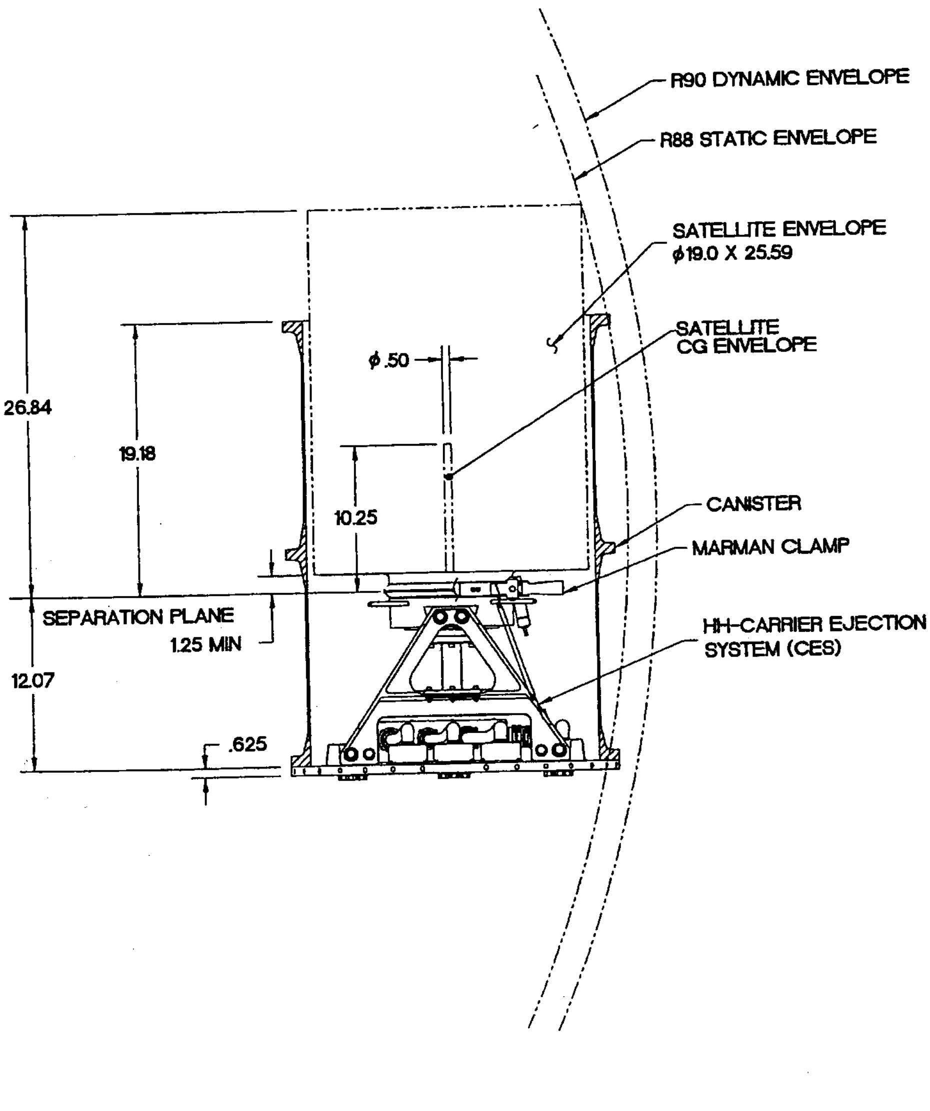


FIGURE 2.76 HITCHHIKER CARRIER EJECTION SYSTEM WITH OPEN CANISTER

PALLET EJECTION SYSTEM WITH DOOR

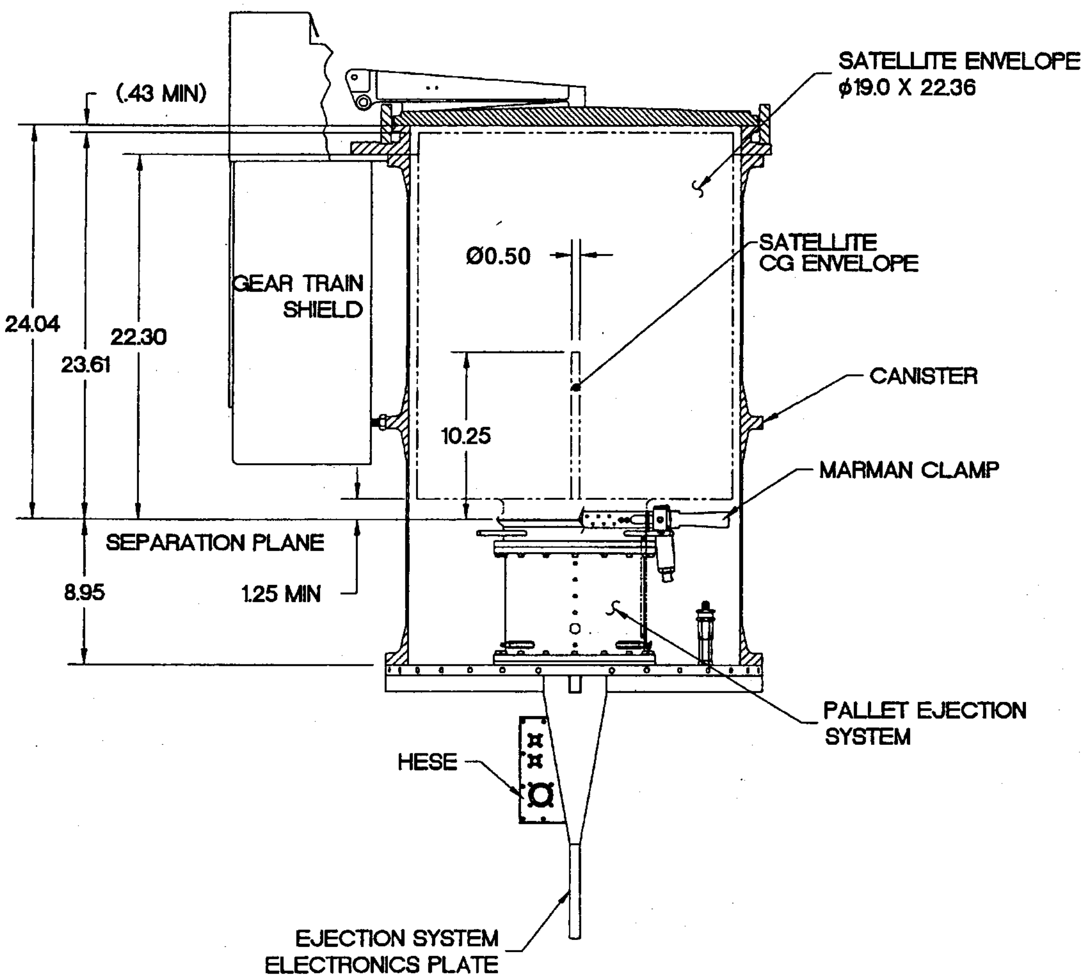


FIGURE 2.77 PALLET EJECTION SYSTEM WITH DOOR

PALLET EJECTION SYSTEM WITH OPEN CANISTER

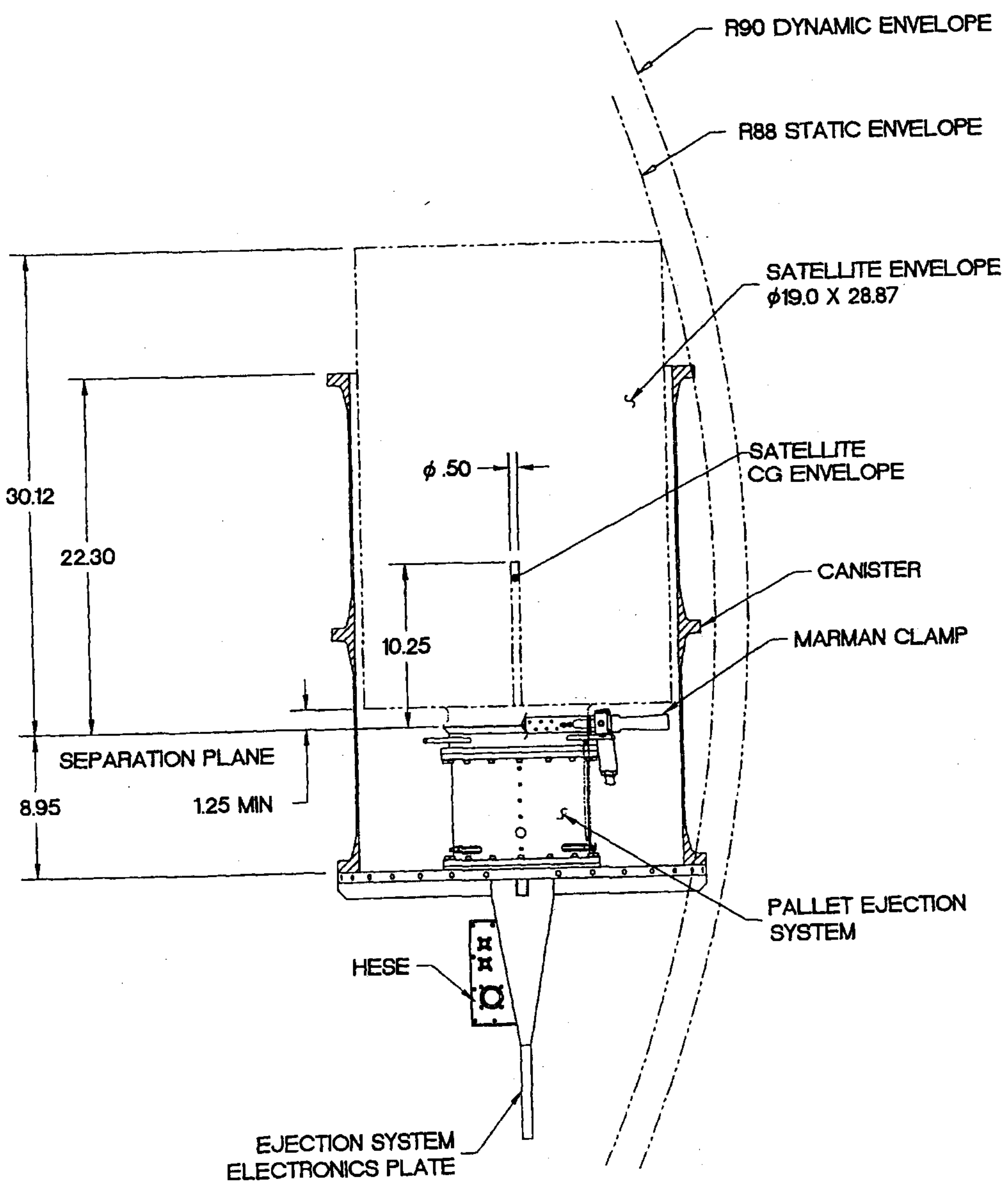


FIGURE 2.78 PALLET EJECTION SYSTEM WITH OPEN CANISTER

PALLET EJECTION SYSTEM
ON SINGLE BAY PALLET

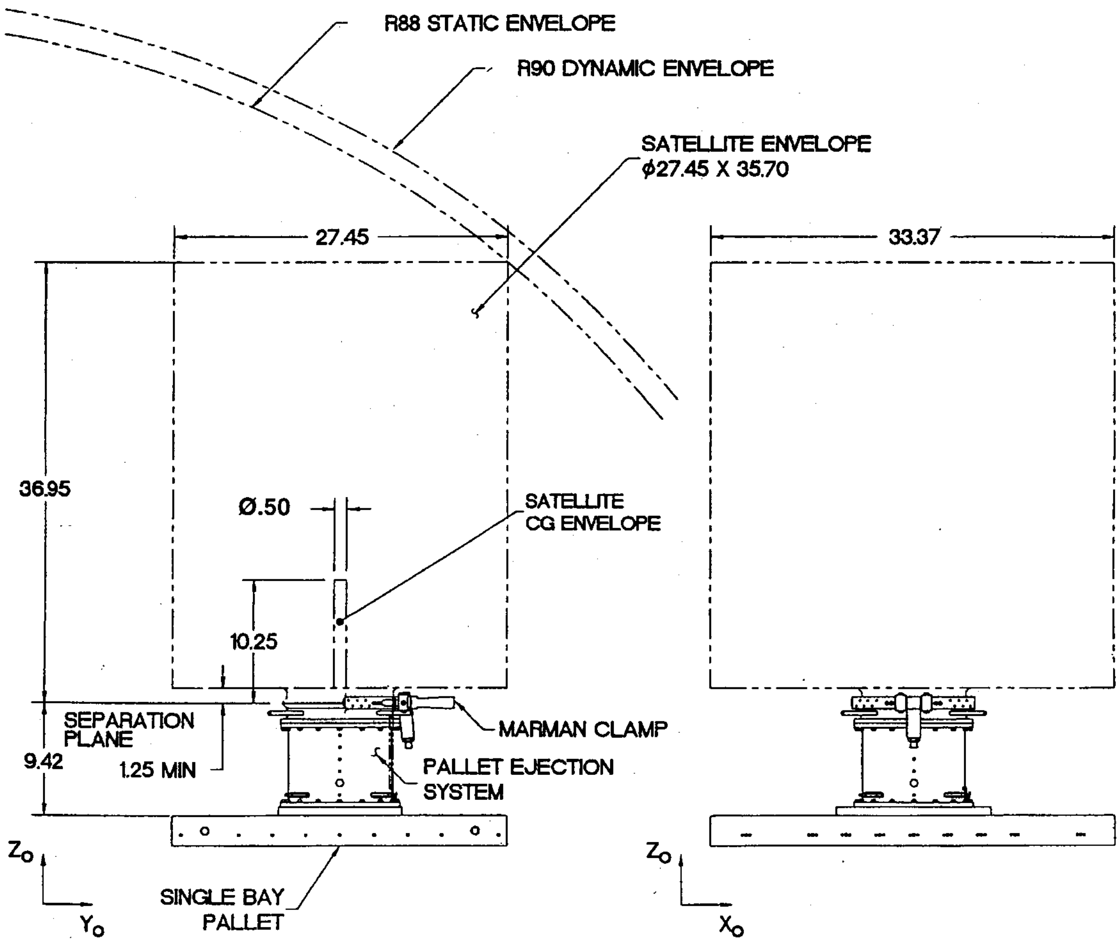


FIGURE 2.79 PALLET EJECTION SYSTEM ON SINGLE BAY PALLET